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IDENTIFIERS *Aircraft Environmental Systems; Military Curriculum Project

ABSTRACT

This publication contains a teaching guide and student instructional materials for conducting a high school or adult vocational education course to train persons to perform duties as an aircraft environmental systems mechanic. Course content has been adapted from a military course. The instructional design for this course is self-paced and/or small group-paced. Instructor materials contained in the course guide include lesson plans detailing training equipment needed, training methods, multiple instructor requirements, and instructional guidance. The student material includes a workbook and programmed texts with review exercises. A bibliography and glossary of terms are provided to aid both teacher and students. The course includes information on organizational and field maintenance of aircraft pressurization, air conditioning, and air starter systems, and life raft inflation equipment. The course is composed of four parts (see note). Block III (contained in this document) is composed of 13 lessons covering 102 hours of instruction. Topics covered are the following: tools, hardware, safety devices, and wire repair; maintenance of moisture separators; maintenance of bleed air distribution ducting; air turbine motor maintenance; turbine refrigeration devices; advanced fighter/bomber air source control system, air conditioning system, and windshield clearing system; maintenance of air control units; anti-G suit system; canopy seal system; pressurization systems; and cabin pressure leakage check.

(KC)

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Military Curriculum Materials for Vocational and Technical Education

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AIRCRAFT ENVIRONMENTAL SYSTEM MECHANIC, 2-9
BLOCK III - AIRCRAFT ENVIRONMENTAL SYSTEMS
UNITS



THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY
1960 KENNY ROAD - COLUMBUS, OHIO 43210

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

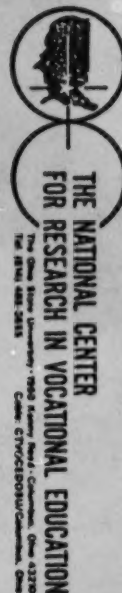
The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT Military Curriculum Materials

WRITE OR CALL

Program Information Office
The National Center for Research in Vocational
Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/
848-4815 within the continental U.S.
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Military Curriculum Materials for Vocational and Technical Education

Information and Field
Services Division

The National Center for Research
in Vocational Education



Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse
Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

Agriculture	Food Service
Aviation	Health
Building & Construction	Heating & Air Conditioning
Trades	Machine Shop
Clerical	Management & Supervision
Occupations	Meteorology & Navigation
Communications	Photography
Drafting	Public Service
Electronics	
Engine Mechanics	

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

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National Center Clearinghouse

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X Materials are recommended but not provided.



Course Description

The instructional design for this course is self-paced and/or small group paced. This course trains personnel to perform duties as an Aircraft Environmental Systems Mechanic. It includes organizational and field maintenance of aircraft pressurization, air conditioning, and air starter systems, and life raft inflation equipment.

- Block I - Fundamentals contains 24 lessons requiring 115 hours of instruction. These are: safety; aircraft familiarization; physics; electron theory; magnetism; DC generation and basic circuit symbols and terms; wiring diagram fundamentals; control and protective devices; multimeter; Kirchoff's current law; Kirchoff's voltage law; Ohm's law; series circuits; parallel circuits; series-parallel circuits; switching circuits; DC motors and control circuit; temperature control circuits; alternating current; capacitance; inductance; AC motors and control circuits; solid state devices; magnetic amplifiers; and trainer aircraft air conditioning system.
- Block II - Air Conditioning Systems consists of 8 lessons convering 124 hours of instruction. These are: fighter cabin air conditioning system; rain removal system; equipment air conditioning system; temperature control system tester; bomber air conditioning system; decade resistor functions and windshield amplifier bench check; cargo bleed air and anti-icing system; and cargo air conditioning system.
- Block III - Aircraft Environmental Systems Units contains 13 lessons covering 102 hours of instruction. These are the following: tools, hardware, safetying devices, and wire repair; maintenance of moisture separators; maintenance of bleed air distribution ducting; air turbine motor maintenance; turbine refrigeration devices; advanced fighter/bomber air source control system; advanced fighter/bomber air conditioning system; advanced fighter/bomber windshield clearing system; maintenance of air control units; anti-G suit system; canopy seal system; pressurization systems; and cabin pressure leakage check.
- Block IV - Utility Systems and Flight Line Maintenance consists of 9 lessons requiring 114.5 hours of instruction. These lessons are entitled: gaseous O₂ systems; liquid O₂ systems; liquid refrigeration systems and components; inspection maintenance of O₂ systems (liquid); cryotainer systems maintenance; liferaft inflation equipment, fire extinguisher system maintenance; flight line maintenance - inspections; and flight line maintenance; removal and replacement of system components.

This course contains both teacher and student materials. Printed instructor materials include plans of instruction detailing training equipment needed, training methods, multiple instructor requirements and instructional guidance. The student material includes workbook, and programmed texts with review exercises. A bibliography and glossary of terms have been provided to aid both the instructor and the student. In Blocks I and III, lessons on Orientation, Security, Progression in Career Field, Maintenance Management, and the Technical Order Publications Systems have been deleted because of military specific materials.

Technical Training

Aircraft Pneudraulic Systems Mechanic
Aircraft Environmental Systems Mechanic

MAINTENANCE TOOLS

24 June 1977



3350 TECHNICAL TRAINING WING
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

This programmed text was prepared for use in the 3ABR42334 Instructional System. It was validated using 30 students in the 3ABR42334 Course. At least 80% of the students achieved the objectives as stated. The average time required to complete the text is 4.3 hours.

OBJECTIVES

1. Match the tool shown in the sketch with the name of the item, in the list of tools given with 80% accuracy.
2. Match each tool given with the correct statement of its purpose, care or use, with 80% accuracy.

INSTRUCTIONS

This text is presented in small steps called frames. After each frame you will select correct statements, match names, and/or numbers to the description and/or use of maintenance tools. Compare your answer with the correct one found at the bottom of the following frame. If your answer is correct, go to the next frame. If your answer is wrong, read the frame again and see how the correct response was derived. READ CAREFULLY AND DO NOT HURRY!

This text is divided into six sections.

Section I	Page 3	Frames 1 through 14
Section II	Page 20	Frames 15 through 30
Section III	Page 40	Frames 31 through 40
Section IV	Page 52	Frames 41 through 63
Section V	Page 83	Frames 64 through 84
Section VI	Page 105	Frame 85

Turn to frame 1 and begin.

OPR: 3370 TTG
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 3370 TTGTC - 600; TTVSR - 1

When we mention tools we may think of several general types and uses for tools. This is why several tools will be found in your tool box. Each is designed for a special purpose. The tools included in most toolkits are described in this text.

Handtools are the mechanic's best friend, he is helpless without them. Regardless of the type of job a mechanic is assigned, he must choose the right tool and be sure to use it correctly. Without a thorough knowledge of the right way to use tools, the mechanic wastes time, cuts down his efficiency, and may injure himself. Mechanic's tools are designed very carefully to do a job. Tools must be used properly if they are to be as effective as the manufacturer intended. Many people think that tools can stand all kinds of punishment. Any mechanic who has this opinion is inviting a lot of grief and possible injury.

//////////No Response Required//////////

Hammers are tools used to strike, drive, pound, etc. Hammers are made up of a head and a handle. The head is made up of one or more faces which may be round, square, or rectangular and concave, flat or convex. The head has a hole which is usually oval-shaped and bell-mouthed at each end. The shape of the eye makes it easy to put in and clamp the handle to the head.

Each hammer has its own special use. The good mechanic learns to select the correct hammer for the particular work at hand.



Match the hammers above to the nomenclatures below:

- _____ 1. Hammer, hand, machinist, ball peen, 1 lb.
- _____ 2. Hammer, hand, face diameter 1 1/2 inch, screw-in inserted face, plastic, 1 1/4 lb.

Hammers are generally classified as "hard face" hammers and "soft face" hammers. Hard face hammers are made of steel. Soft face hammers have a face made of material softer than steel, for example: lead, plastic, rubber, wood or brass.

Hammers are further classified according to the weight of the head (without the handle) and they range from four ounces to 20 pounds in size.

Answer each of the following statements as either true (T) or false (F).

- ___ 1. Hammer size is determined by the weight of the hammer head.
- ___ 2. Soft face hammers are made of steel.
- ___ 3. Hard face hammers are made of such materials as lead, plastic or rubber.

Answers to Frame 2: 1. b 2. a

One of the better known hard face hammers is the ball peen hammer. The name of this hammer came from the ball-shaped end which is used to peen (expand or stretch) metal. The ball-peen hammer is frequently used to expand the end of a rivet in a hole or for forming gaskets. The flat-faced end of the hammer is used for tapping a punch or a chisel or for other rough work.

Ball-peen hammers come in different sizes (weight). The size of these hammers is given in weight of the head in ounces. The most commonly used hammer is a 12-ounce hammer. Although six to eight ounce hammers, for light work, and 16 to 32 ounce hammers, for heavy work, are available. The type of work that you do should determine which weight hammer you will use.

Check (✓) the true statements below.

- _____ 1. The flat-faced end of the ball-peen hammer is used when riveting.
- _____ 2. Ball-peen hammers are used where steel hammers may mar the work.
- _____ 3. The weight of the head determines the size of the hammer.

Answers to Frame 3: 1. T 2. F 3. F

Soft-faced hammers are used to form soft metals or to drive close-fitting parts together. The soft material on the face of these hammers can be damaged easily. Therefore, soft-faced hammers should not be used for rough work such as driving a punch, nails or bolts.

Mallets are also available in your shop. The only difference in a mallet and a soft-faced hammer is that the entire head of a mallet is made up of rubber, brass, or plastic. However, only the face of a soft-faced hammer is made up of these materials.

2. Match each of the hammers in column B with the proper use in column A.

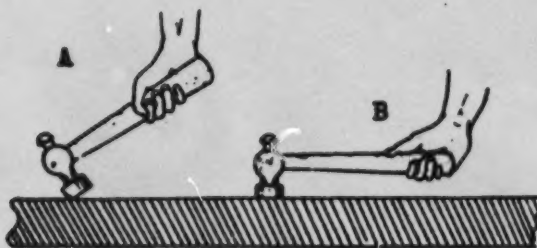
Column A	Column B
1. _____ Used for forming gaskets and other light work.	a. Mallet
2. _____ The entire head is composed of rawhide to prevent injury.	b. Ball-peen hammer
3. _____ Brass-faced hammer used where steel hammer may mar the work.	c. Soft-faced hammer

Answers to Frame 4: 1. _____ 2. _____ 3. ✓

Practice is the only way that you will learn to use a hammer properly. However, the correct grip is an aid to a hammer's right use.

The handle should be held near the end with the fingers underneath and the thumb along the top or side. The thumb should always rest on the handle itself, never on top of the fingers. The grip should be tight enough to control the blow. The blow is delivered so the face of the hammer is parallel to the work being struck.

A blow off the side of the object being struck is usually caused by grease or oil on the face of the head. Should this happen, the face should be wiped off with a rag and then rubbed briskly with coarse sandpaper or emery cloth.



1. Study the illustration above, then answer the questions below.

a. The correct way to hold and deliver a blow with a hammer is shown by drawing ____.

2. Check (✓) the true statements below.

- ____ a. While using a hammer, always hold it near the end of the handle.
- ____ b. When delivering a blow with a hammer, the thumb must rest on top of the fingers.
- ____ c. The face of the hammer must squarely meet the object being struck.

Answers to Frame 5: 1. b 2. a 3. c

Probably most accidents with hammers are caused by loose hammer heads, sweaty hands, or oily or greasy handles. The user should pay close attention to these dangers when using a hammer.

Never use a hammer with a loose head or a cracked handle, as this is dangerous to both the material being worked on and to other personnel. A loose head can be tightened by driving the wedge, found in the end of the handle, in, flush with the head. If the head starts to work off the end of the handle, it can be set back in the proper position by striking the butt end of the handle against a solid object. After the head has been moved back to its correct position, it should be tightened by driving the wedge into the handle in the eye of the head. If any defects are noticed, it should be repaired or turned in for a serviceable hammer.

Check (✓) the true statements below.

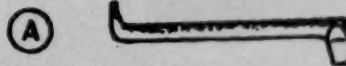
- ☐ 1. A cracked hammer handle should be glued or taped before using.
- ☐ 2. If you can't repair a hammer, you should turn it in for a serviceable one.
- ☐ 3. A loose hammer head can be set back by striking the butt end of the handle against a solid object.

Answers to Frame 6: 1. a. B

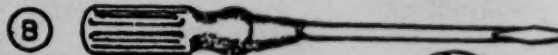
2. a. ✓ b. c. ✓

Screwdrivers are grouped by the types of points they have. The screwdrivers points are: common, crosspoint, and clutchhead. Study the illustrations below, of the four screwdrivers, and read their description.

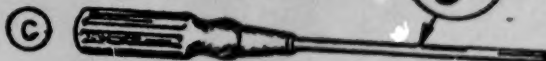
The offset screwdriver has a sharp bend at each end. It has flat tips or crosspoints.



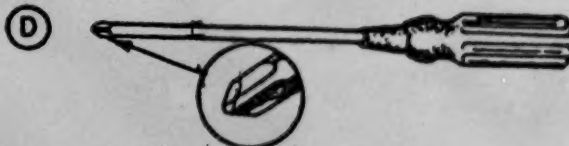
You should be familiar with the common screwdriver - it has a flat tip.



The clutchhead screwdriver stands alone in that it does not look like any other type.



The crosspoint screwdriver family includes both the Phillips, and the Reed & Prince types.



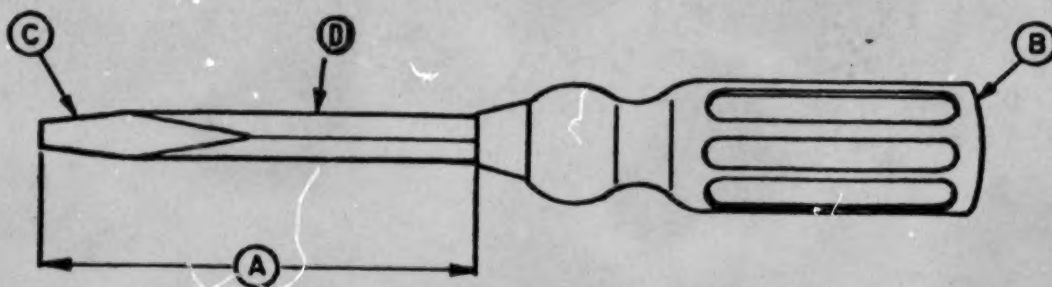
Match the items shown above with the nomenclature below:

- ___ 1. Screwdriver, flat tip, 3/8-inch wide tip, 6-inch long blade.
- ___ 2. Screwdriver, crosspoint, 6-inch long blade.
- ___ 3. Screwdriver, flat tip, offset, 4 1/2-inch long.
- ___ 4. Screwdriver, clutchhead, 6-inch long blade.

Answers to Frame 7: 1. ___ 2. ☒ 3. ☒

A common screwdriver is sometimes called a flat tip screwdriver. This is because the working edge of the blade is ground flat and straight and not a sharp edge like a knife or chisel blade. The common screwdriver, shown below, has a steel shank set in a handle of wood or plastic.

The size of all screwdrivers is the combined length (in inches) of the blade and shank. Can you name the parts of the drawing below? Part D is the shank. It is steel and usually round in shape. However, some heavy duty screwdrivers may have a square shank. Part C of the illustration is the blade. The blade is the working part of the screwdriver. The blade is ground flat and straight for the best possible contact. Part B of the illustration is the handle which is made of wood, plastic, or other nonconductor of electricity.

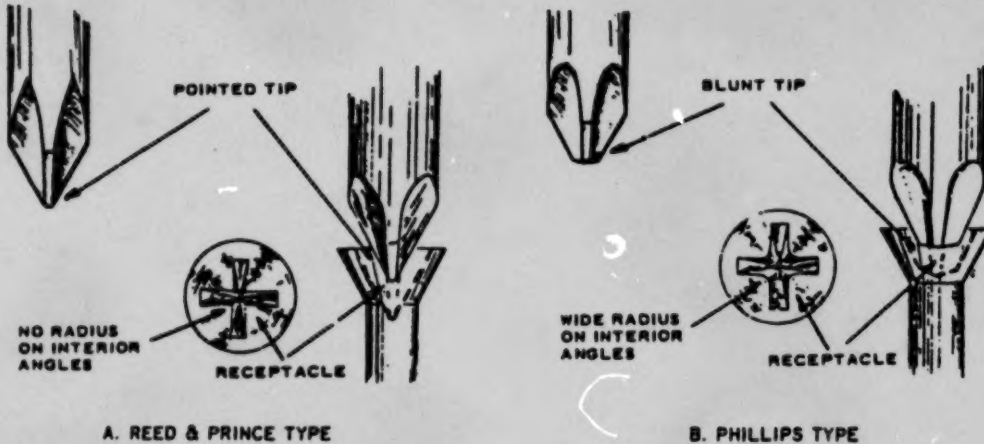


1. Match the items lettered in the drawing above with the statements listed below:

- ___ 1. Shank
- ___ 2. Handle
- ___ 3. Blade
- ___ 4. Dimension used to determine the specified length of a screwdriver.

Answers to Frame 8: 1. B 2. D 3. A 4. C

The crosspoint screwdrivers, shown in the illustration below, are made to fit a specific screw or bolt. The Reed and Prince crosspoint tip should be used only on a Reed and Prince screw. The Phillips screwdriver is designed for use with only a Phillips screw. Look at the difference in the shapes of the points and flutes (rounded grooves). Use of the wrong size or type of crosspoint screwdriver will result in damaged screwheads and unnecessary loss of man-hours in replacing them.

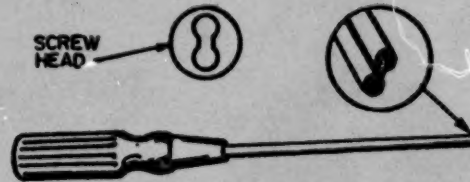


Mark the following statements true (T) or false (F).

- ___ 1. When removing an AGE unit inspection plate, it is best to observe the exact fit of the crosspoint screwdriver and change to the correct type as required.
- ___ 2. The Reed and Prince screwdriver has a sharper point than the Phillips type.
- ___ 3. The size of the screwdriver is determined by the length of the shank and blade.
- ___ 4. The phillips screwdriver can be used on a Reed and Prince screwhead.

Answers to Frame 9: 1. D 2. B 3. C 4. A

Some equipment, especially assembly line made goods, use clutch-head screws. Their design is similar to a figure eight (see illustration). This type of screwhead is used because the screw can be easily put in with power tools and not strip the screwhead. A clutchhead screwdriver must be used to put in or take out clutchhead screws. Otherwise, damage to the screwhead will occur.

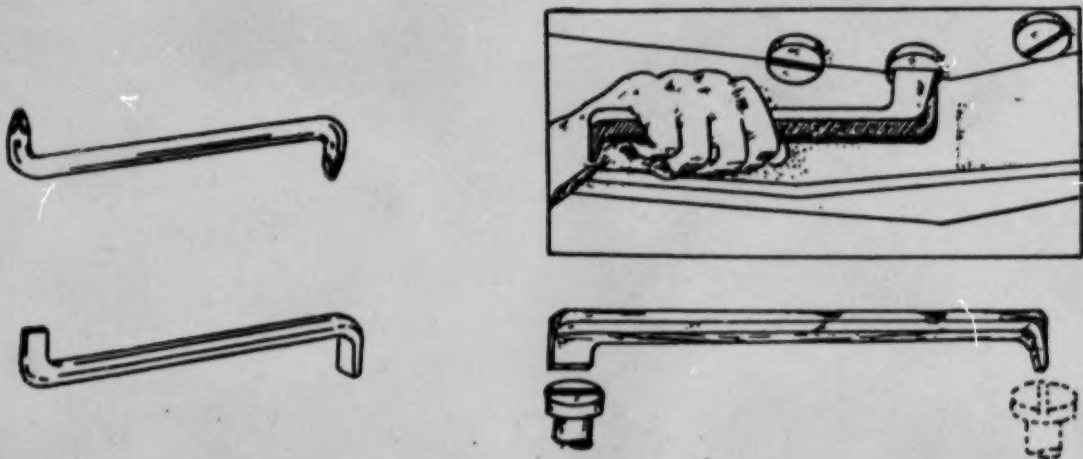


1. Check (✓) the true statements below.

- _____ 1. If the shank of a clutchhead screwdriver is ten inches long and its handle is four inches long, it is a ten inch screwdriver.
- _____ 2. The clutchhead screwdriver has a sharply pointed tip.
- _____ 3. The clutchhead screwdriver tip resembles a figure eight.

Answers to Frame 10: 1. T 2. T 3. T 4. F

The offset screwdriver is used to put in, take out, or adjust screws which cannot be reached by other screwdrivers. (See illustration below). Offset screwdrivers come with a crosspoint for Reed and Prince and Phillips screwheads or flat tips for common and slotted screwheads. Each end of the flat tip offset screwdriver has a blade bent at a right angle (90 degree) to the shank. The working edge of one blade is parallel to the shank; the other is set at a 90 degree angle to the shank. By alternating the use of the blades, a screw can be tightened or loosened with very little movement. This feature makes this tool indispensable in tight corners where other types of screwdrivers will not enter.



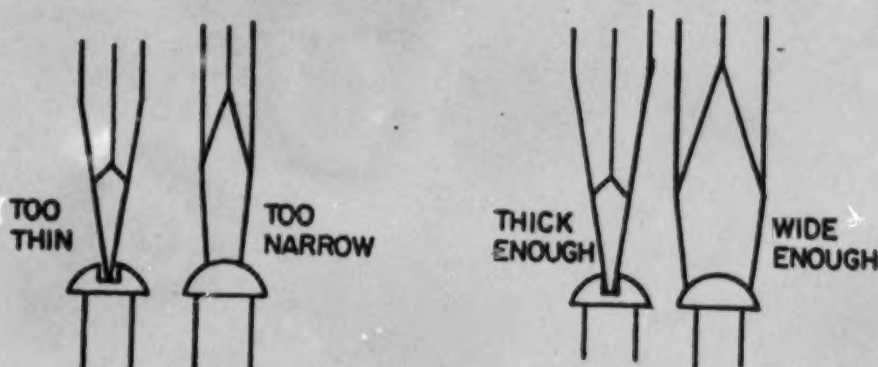
1. Check (✓) the true statements below.

- ☐ 1. An offset screwdriver has a tip like any other screwdriver, except that it has a sharp bend at each end.
- ☐ 2. The two tips on an offset screwdriver are for use on different sized screwheads.
- ☐ 3. An offset screwdriver may be used in a limited access area where a longer screwdriver cannot be used.

Answers to Frame 11: 1. ☒ 2. ☐ 3. ☒

Screwdrivers should only be used to put in or take out screws. They are not designed nor intended to be used as a chisel, a punch, a pry, a nail puller, or a hammer. While being used for its intended purpose, sufficient pressure should be put on to stop it from climbing out of the slot. Most accidents with screwdrivers are caused by the blade slipping out of the screw slot. All users should exercise caution to prevent slipping. They should also avoid holding any part of their body where a slipping screwdriver could cause injury. Never use a screwdriver to check electrical circuits.

When you select a screwdriver, select the largest one whose blade will make a good fit in the screw slot. This will prevent burring of the slot and damage to the blade. It will also reduce the force required to hold the blade in the slot.

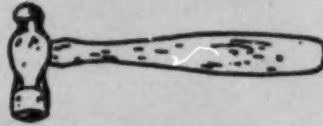


Check (✓) the correct statements below.

- ___ 1. An important factor to consider when selecting a screwdriver for a particular screw is the size of the blade.
- ___ 2. Damage to screwheads and screwdrivers is reduced when the proper size screwdriver is used.
- ___ 3. It is important that the correct amount of pressure be applied to the screwdriver when installing or removing screws.
- ___ 4. A screwdriver should never be used as a chisel, punch, prybar or nail puller.

Answers to Frame 12: 1. 1. ✓ 2. ___ 3. ✓

Test your knowledge of the previous frames by answering the following questions. If you miss any, go back and review the appropriate frame.



1. This handtool is called a
 - a. mallet.
 - b. sledge hammer.
 - c. ball peen hammer.
 - d. plastic hammer.
2. Hammer size is determined by the
 - a. length of the handle.
 - b. diameter of the face.
 - c. weight of the hammer head.
 - d. weight of the hammer head and handle combined.
3. Soft face hammers have a face made of
 - a. lead.
 - b. brass.
 - c. plastic.
 - d. any of the above.
4. When delivering a blow with a hammer, hold the hammer
 - a. with your thumb resting on top of the fingers.
 - b. near the end of the handle.
 - c. so the face will strike the object at an angle.
 - d. wherever it feels most comfortable to the user.



5. What type of screwdriver is used for the above screwhead?
- a. Offset flat tip screwdriver.
 - b. Crosspoint screwdriver.
 - c. Common screwdriver.
 - d. Clutchhead screwdriver.



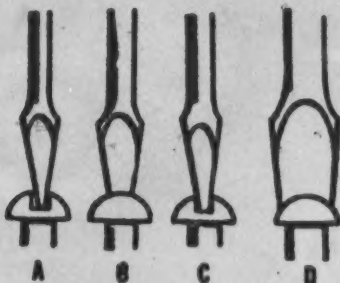
6. What type of screwdriver is used for the above screwhead?
- a. Offset crosspoint screwdriver.
 - b. Crosspoint screwdriver.
 - c. Common screwdriver.
 - d. Clutchhead screwdriver.



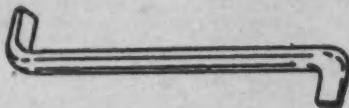
7. What type of screwdriver is used for the above screwhead?
- a. Offset flat tip screwdriver.
 - b. Crosspoint screwdriver.
 - c. Common screwdriver.
 - d. Clutchhead screwdriver.

8. What type of screwdriver is best used in tight quarters?
- a. Offset screwdriver.
 - b. Crosspoint screwdriver.
 - c. Common screwdriver.
 - d. Clutchhead screwdriver.

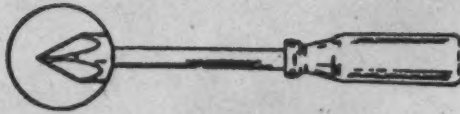
9. The size of a screwdriver is determined by the
- size of the blade.
 - size of the handle.
 - length of the screwdriver.
 - combined length of the blade and the shank.



10. Which of the above illustrations shows the correct size of screwdrivers to use?
- B and C
 - A and D
 - A and B
 - C and D



11. What tool is pictured above?
- Flat tip screwdriver.
 - Crosstip screwdriver.
 - Crosstip offset screwdriver.
 - Offset flat tip screwdriver.



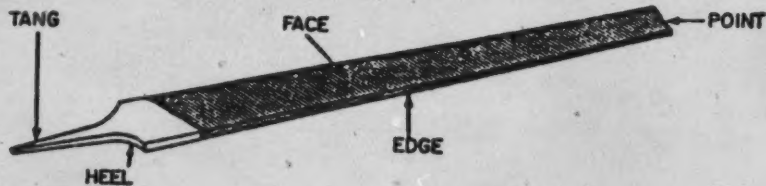
12. What tool is pictured above?

- a. Crosstip (Phillips) screwdriver.
- b. Crosstip (Reed and Prince) screwdriver.
- c. Crosstip offset screwdriver.
- d. Common screwdriver.

Answers to Frame 13: 1. ✓ 2. ✓ 3. ✓ 4. ✓

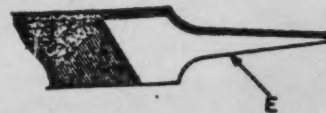
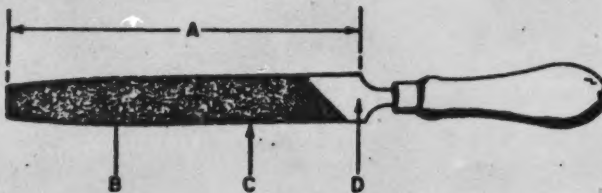
Frame 15

A file is a precisely made tool of hardened steel. You use it to cuff, smooth, or remove small parts of metal. Files have a cutting edge across the face. Some files have a cutting edge on both the face and the edge. The names of the parts of a file are shown in the drawing below.



File size is its length, in inches, from the point to the heel.
NOTE: Never use a file without a handle as the tang could be driven into your hand.

Match the lettered items in the drawings with the statements below.



- | | |
|--------------------|------------------|
| ___ 1. File length | ___ 4. File face |
| ___ 2. File tang | ___ 5. File heel |
| ___ 3. File edge | |

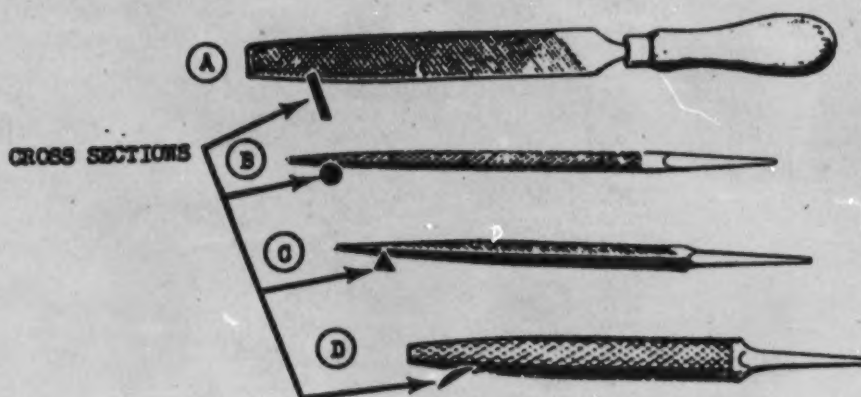
Answers to Frame 14:

Question No	Answer	Review Frame	Question No	Answer	Review Frame
1. - - - - -	c - - - - -	2	7. - - - - -	d - - - - -	11
2. - - - - -	c - - - - -	4	8. - - - - -	a - - - - -	12
3. - - - - -	d - - - - -	3	9. - - - - -	d - - - - -	9
4. - - - - -	b - - - - -	6	10. - - - - -	d - - - - -	13
5. - - - - -	b - - - - -	10	11. - - - - -	d - - - - -	12
6. - - - - -	c - - - - -	9	12. - - - - -	b - - - - -	10

Files come in a number of shapes so that you will have a tool for every job. Some cross-section views of file shapes are shown in the illustration below.



Files of different shapes are given specific names. Each file is also designed for a specific purpose. A flat file (illustration A) is used to file a flat surface or edge. A round file (illustration B) sometimes known as a rattail file, is used to enlarge a round hole. A taper file (illustration C) is used for various filing operations such as sharpening saw blades or filing small parts. A half-round (illustration D) may be used on a flat or concave (hollow and curved) surface or edge.



1. Match the items illustrated above with the nomenclature given below.

- ___ 1. File, hand, round, 8-inch (rattail file).
- ___ 2. File, hand, half-round, 8-inch.
- ___ 3. File, hand, flat, 10-inch.
- ___ 4. File, hand, taper, 8-inch.

1871

Frame 16 Continued

2. Check (✓) the true statements below.

- ☐ 1. You should use a taper file for enlarging a round hole.
- ☐ 2. A half-round file should be used for filing a concave hole.
- ☐ 3. Use a flat file for removing a small amount of metal on a straight flat edge.
- ☐ 4. The tang is the file handle.

Answers to Frame 15: 1. A 2. E 3. C 4. B 5. D

The cut of a file refers to both kind and coarseness of the teeth. The kind of teeth refers to how the cutting teeth are aligned. Files have either single-cut or double-cut teeth. Single-cut files have rows of teeth cut parallel to each other.

Double-cut files have criss-cross rows of teeth. The single-cut files are for fine, detailed work. The double-cut files are used for quick removal of metal and for rough work.

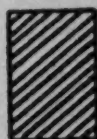


Single-Cut

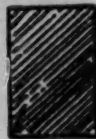


Double-Cut

The coarseness of cut for a file is determined by the spacing (distance between the teeth) and size of the teeth. Three classes of file coarseness are shown in the drawings below.



Bastard



Second Cut



Smooth

Match the cut of a file in column B to the proper description listed in column A by placing the letter in the space provided.

Column A

- ___ 1. Rows of teeth parallel to each other
- ___ 2. Rows of teeth that criss-cross each other
- ___ 3. A file with teeth cut deep and far apart
- ___ 4. A file with teeth cut shallow and close together.

Column B

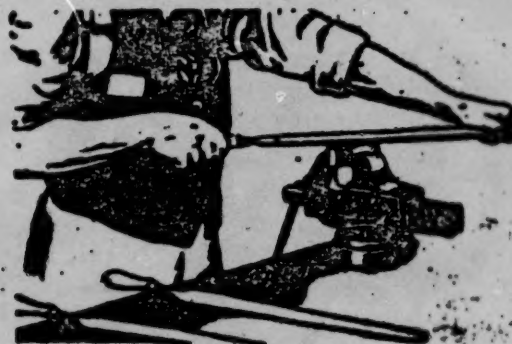
- a. double-cut file
- b. smooth grade file
- c. single-cut file
- d. bastard grade file
- e. rasp-cut file

Answers to Frame 16: 1. 1. B 2. D 3. A 4. C 2. 1. 2. ✓
3. ✓ 4.

The file picked for any kind of job depends on the material being worked and the finish desired. For soft materials use a coarse file. For hard materials use a fine file. For a very accurate finish use a very smooth file. For rough work use a coarse file.

A file should never be used without a handle. Without a handle it is not only hard to control but it is also likely to pierce your hand. The handle should be tight on the tang of the file.

The handle of a file should be held (by a right handed person) in the right hand with the fingers underneath and the thumb on top. The left hand should grip the point of the file between the palm and fingers. This will give you the greatest control of the file. For very accurate finishes, the thumb and fingers of the left hand should rest on top of or lightly grip the point of the file. This is shown in the illustration.



A file should never be used on a material harder than itself, or on scaly materials. This will break the teeth and make the file useless.

Mark the following statements true (T) or false (F).

- ___ 1. A right handed filer should hold the handle of the file in his right hand with the fingers on the top and the thumb on the heel.
- ___ 2. For accurate finishes, the thumb and fingers of the left hand should rest on top of the file or lightly grip the point of the file.
- ___ 3. A left handed filer should hold the handle of the file in his left hand with his fingers underneath and the thumb on top of the handle.

Answers to Frame 17: 1. C 2. A 3. D 4. B

The way you use a file varies with the work to be done and the type of file to be used. However, the general procedure is as follows: Use a smooth, firm forward stroke to "cut" the material being filed. Use only enough pressure to keep the file cutting. DO NOT drag the file during the return stroke or the teeth may be dulled.

Not enough pressure on the forward stroke will cause the file teeth to slip over the work, resulting in dulled file teeth. Too much pressure will overload the file teeth, causing the cut to be irregular.

1. Answer each of the following statements as true (T) or false (F).

- ___ 1. The procedure for using a file is the same for every job.
- ___ 2. The teeth of a file can be dulled if the file is used improperly.
- ___ 3. The procedure for using a file is not the same for every job.
- ___ 4. In order for the file to cut the material, a lot of pressure must be applied.

2. Match the improper use of a file (column A) to the condition it will cause (column B).

Column A

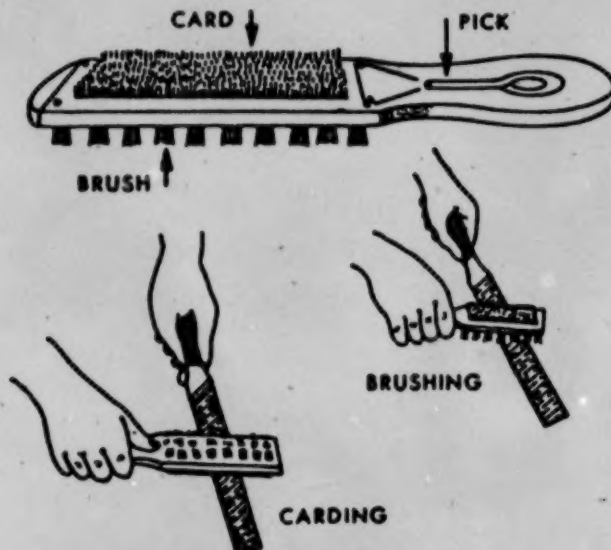
- ___ 1. Insufficient pressure
- ___ 2. Excessive pressure

Column B

- a. irregular cut
- b. dulled teeth
- c. broken file

Answers to Frame 18: 1. F 2. T 3. T

When you use a file you will get small chips or filings. Filings often wedge between the file teeth and reduce the cutting action. Clean a file by brushing it with a wire brush, called a file card (see figure below). Push the file card in a direction parallel with the file teeth. The reverse side of the file card contains a fiber brush. It is used for brushing the file after carding. A metal pick may be removed from the handle of the file card. The pick aids in removing metal filings that cannot be removed otherwise. After cleaning a file it should be wrapped in cloth or paper and placed in your toolkit. Wrapping protects the teeth.



1. Check (✓) the true statements below.

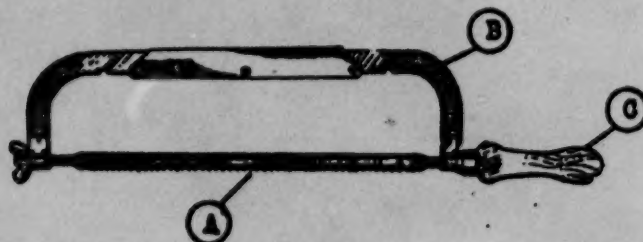
- ___ 1. To clean a file, use the card before the fiber brush.
___ 2. Files should be cleaned and wrapped after use.

Answers to Frame 19: 1. 1. F 2. T 3. T 4. F
2. 1. B 2. A

Hacksaws, used for cutting metal, have either adjustable frames or solid frames. Adjustable frames can be changed to hold blades from eight to sixteen inches in length. Solid frames, although more rigid, will take only the blade length for which they are made. The length is the distance between the two pins which hold the blade in place. These pins can be adjusted within the frame to hold the blade parallel to or at right angles to the frame. To make a cut deeper than the frame will permit, the blade is turned sideways (at right angles to the frame). All frames, either solid or adjustable, have adjustment screws for drawing the blade tight.

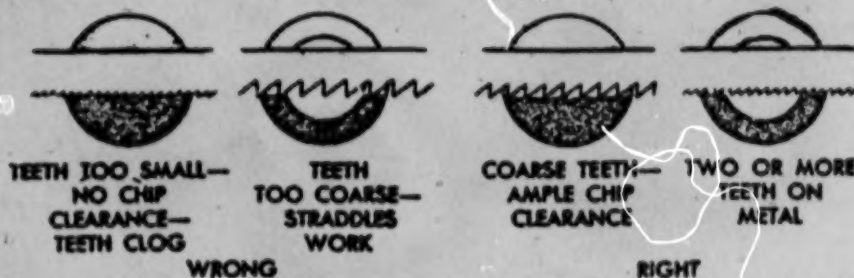
1. Match the items lettered in the drawing on the right with the parts of the hacksaw as listed on the left.

- ___ 1. Frame
___ 2. Handle
___ 3. Blade



Answers to Frame 20: 1. 1. ✓ 2. ✓

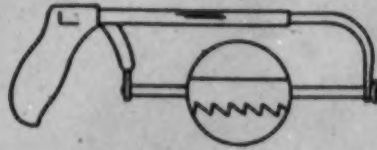
The drawings below show the way to pick saw blades that are the most suitable for a job. Study the drawings carefully and then answer each of the following statements as being either true (T) or false (F).



- ___ 1. Hacksaw blades are available with different numbers of teeth per inch.
- ___ 2. When cutting thin materials with a hacksaw a large toothed hacksaw blade should be used.
- ___ 3. When cutting large stock with a hacksaw a small toothed hacksaw blade should be used.

Answers to Frame 21: 1. 1. B 2. 2. C 3. 3. A

The drawing below shows the right way to mount a blade in the frame.



When you use the hacksaw, always apply pressure on the forward stroke. This is necessary because the cutting teeth of the hacksaw blade point forward. The teeth do not cut on the back stroke; thus you should not apply pressure on the back stroke.

Answer each of the following statements as either true (T) or false (F).

- ___ 1. When using a hacksaw, pressure is applied to the saw on the forward stroke only.
- ___ 2. Hacksaw blades are replaceable.
- ___ 3. Some hacksaw frames are adjustable for different blade lengths.
- ___ 4. Hacksaw blades are installed in the frame with the teeth pointing backward (toward the handle).

Answers to Frame 22: 1. T 2. F 3. F

The use of a hacksaw is much like the use of a file. The work should be held rigid. The cutting stroke should be as long as possible. There should not be over 60 strokes per minute. Pressure should be applied on the forward stroke only.

The blade should be kept straight and in line with the cut, otherwise the blade may be cramped and broken. When the work is nearly cut through, the pressure on the saw should be taken off. This stops the teeth from catching. Special care is needed toward the end of a cut through thin material. When cutting very thin stock, it is wise to clamp the work between two pieces of wood and saw through all three pieces. This prevents chattering and possible damage to the work.

The chief danger when using the hacksaws is injury to the hand, should the blade break, and they do break. The blade will break if the user bears down too hard on the cut or does not push the saw in a straight line. If the work is not held tight in a vise it may slip, twisting the blade enough to break it.



WRONG

TOO GREAT FORCE BREAKS BLADE



RIGHT

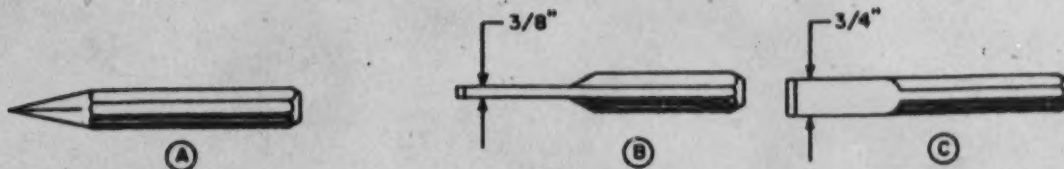
CORRECT FORCE BLADE CUTS
ON FORE STROKE ONLY

Check (✓) the true statements below.

- ___ 1. The cutting stroke should be as short as possible.
- ___ 2. Most of the force you exert on a hacksaw should be downward.
- ___ 3. The greatest danger, when using a hacksaw, is when the blade breaks.

Answers to Frame 23: 1. T 2. T 3. T 4. F

The cold chisel gets its name from the fact that it can be used to cut "cold" metal (without first softening the metal by heating). Chisels are made in a variety of shapes, suited for different types of work. The figure below shows three types of chisels.



1. Match the item below with the correct nomenclature.

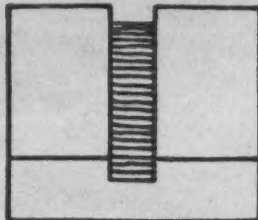
- ___ 1. Chisel, cold, hand, 3/4-inch wide cut, 7 inches long.
- ___ 2. Chisel, cape, hand, 3/8-inch wide cut.
- ___ 3. Chisel, diamond point, hand.

Answers to Frame 24: 1. ___ 2. ___ 3. ✓

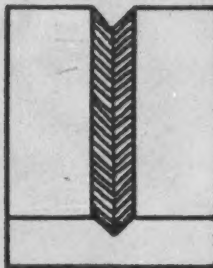
Match each chisel in Column B with the correct use in Column A.

Column A

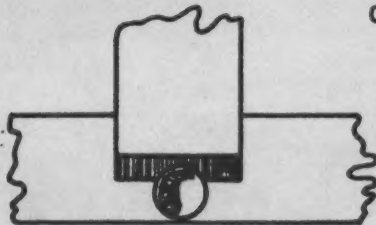
- ___ 1. To cut narrow grooves in metal.



- ___ 2. To cut "v" grooves in metal.



- ___ 3. To cut the heads off rivets.



Column B

- A Diamond point chisel.



- B Flat chisel. (cold)



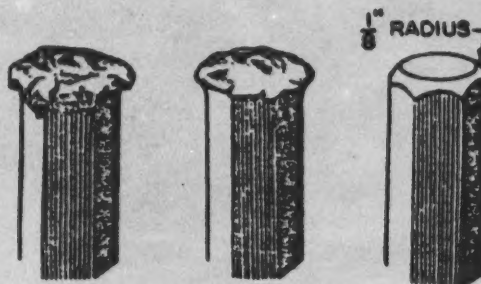
- C Cape chisel.



Answers to Frame 25: 1. 1. C 2. B 3. A

Hammering on a chisel may cause its head to be mushroomed (see figure below). A chisel in this shape should not be used. The bent-over edges may break off and hurt you.

The chisel at the left is badly mushroomed. The one in the center is slightly mushroomed. Both chisels should be dressed until they are in the condition shown at the right.



1. Answer the following statement as being either true (T) or false (F).

___ 1. A chisel with a mushroomed head should be dressed on a grinding wheel to remove all cracks and rolled over edges.

2. Match each chisel in column B with the correct use in column A.

Column A

Column B

___ 1. Used to cut off rivet heads, cut sheet metal, and to split nuts.

a. Flat chisel

___ 2. Used for cutting narrow grooves in metal.

b. Cape chisel

___ 3. Used for cutting "v" grooves and squaring corners in metal.

c. Diamond point chisel

Answers to Frame 26: 1. C 2. A 3. B

Punches are made of the same material and need the same care as do cold chisels. The work for which they are best suited depends on their shape. The illustrations and descriptions show three types of punches.

The center punch has a sharp "pointed" end.

The pin punch has a straight point.

The drift punch has a tapered point.



1. Match the items illustrated above with the nomenclature listed below:

- ___ 1. Punch, center, solid, 3/8-inch diameter.
- ___ 2. Punch, drive pin, straight point, 1 1/2-inch long, 5/32-inch diameter.
- ___ 3. Punch, drift, taper 1 1/2-inch long.

Answers to Frame 27: 1. 1. T

2. 1. A 2. B 3. C

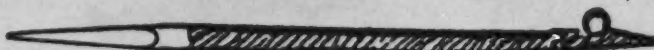
2. Match each tool in column B with the proper use in column A.

Column A	Column B
___ 1. For driving bolts or rivets out of holes.	A. Pin punch
___ 2. For marking the location of holes to be drilled in metal.	B. Flat chisel
___ 3. To align bolt holes of parts for assembly.	C. Drift punch
___ 4. For cutting "V" grooves in metal.	D. Diamond point chisel
___ 5. For cutting narrow grooves in metal.	E. Center punch
___ 6. For cutting the heads off rivets and for splitting nuts.	F. Cape chisel
	F. Cape chisel

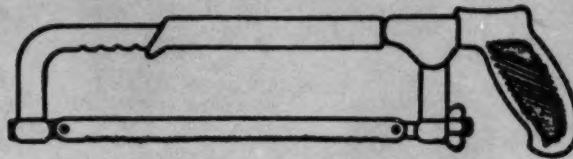
Answers to Frame 28: 1. 1. A 2. B 3. C

If you miss any of the following questions, go back and review the appropriate frame.

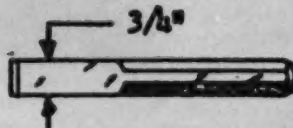
1. The part of the file used when filing is called the
- a. file heel.
 - b. file tang.
 - c. file face.
 - d. file point.



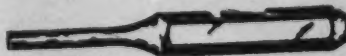
2. The above pictured file is called a
- a. half-round file.
 - b. rattail file.
 - c. taper file.
 - d. flat file.
3. The file best suited for sharpening saw blades is called a
- a. taper file.
 - b. rattail file.
 - c. round file.
 - d. half-round file.
4. Rows of teeth on a file that criss-cross each other are called a
- a. bastard grade file.
 - b. smooth grade file.
 - c. single-cut file.
 - d. double-cut file.
5. A file is properly used when
- a. only slight pressure is applied on the forward stroke.
 - b. even pressure is applied on both, the forward and backward strokes.
 - c. a smooth, firm, forward stroke is used.
 - d. a lot of pressure is applied on the forward stroke, slight pressure is applied on the return stroke.



6. The above illustration represents
- a. an adjustable hacksaw.
 - b. a solid frame hacksaw.
 - c. a jig saw.
 - d. a band saw.
7. The tooth points on a hacksaw blade must
- a. be coarse enough to straddle the work.
 - b. be very small in order to clear the chips away.
 - c. face backwards, towards the handle.
 - d. face forwards, towards the tip of the saw.



8. The above chisel is called a
- a. cape chisel.
 - b. cold chisel.
 - c. diamond point chisel.
 - d. drift chisel.
9. To cut a "V" groove in metal, you use a
- a. hacksaw.
 - b. flat chisel.
 - c. diamond point chisel.
 - d. chassis chisel.



10. The above tool is called a
- a. drift punch.
 - b. pin punch.
 - c. center punch.
 - d. chassis punch.



11. The above tool is called a
 - a. drift punch.
 - b. pin punch.
 - c. center punch.
 - d. chassis punch.
12. To mark the locations of holes to be drilled, you use a
 - a. pin punch.
 - b. drift punch.
 - c. center punch.
 - d. chassis punch.
13. To drive rivets or bolts out of holes, you use a
 - a. pin punch.
 - b. drift punch.
 - c. center punch.
 - d. chassis punch.
14. Chisels and punches that have become mushroomed should be
 - a. used.
 - b. thrown away.
 - c. turned in for a new one.
 - d. dressed on a grinding wheel.

Answers to Frame 29: 1. 1. B 2. A 3. C
 2. 1. A 2. E 3. C 4. D 5. F 6. B

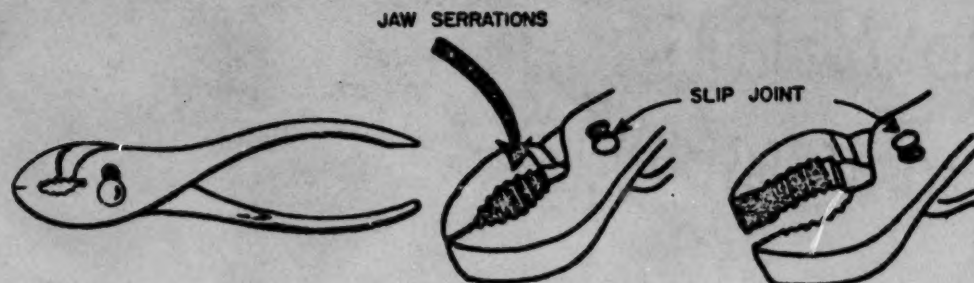
Frame 31

Pliers can be defined as tools designed to hold parts. They are made up of two pieces of steel pivoted off center. The application of pressure to the ends farthest from the pivot point will yield considerably more pressure at the end near the pivot point. Each of the different types of pliers available in the shop are made for one specific use. They should not be used as hammers or to remove and insert nuts and bolts.

NO RESPONSE REQUIRED

Answers to Frame 30:

Question No	Answer	Review Frame	Question No	Answer	Review Frame
1. - - - - -	C - - - - -	15	8. - - - - -	B - - - - -	25
2. - - - - -	B - - - - -	16	9. - - - - -	C - - - - -	26
3. - - - - -	A - - - - -	16	10. - - - - -	B - - - - -	28
4. - - - - -	D - - - - -	17	11. - - - - -	A - - - - -	28
5. - - - - -	C - - - - -	19	12. - - - - -	C - - - - -	29
6. - - - - -	A - - - - -	21	13. - - - - -	A - - - - -	29
7. - - - - -	D - - - - -	23	14. - - - - -	D - - - - -	27

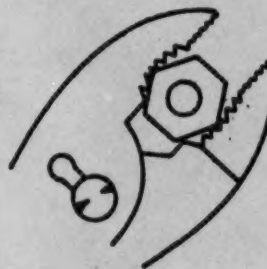


These are known as combination pliers. They have been called "gas" or "common" pliers in the past. Combination pliers are used to hold or bend small pieces of metal to the shape desired. Combination pliers have a slip joint that allows the jaws to be adjusted. This makes it possible to adjust the combination pliers so that they can be used to grip different sized objects.

Combination pliers may be used for many general operations but must never be used on nut and boltheads. To do so may damage the nut or bolt, and may damage the plier jaw serrations. Pliers usually mar the surface of any material, so be careful when using the tools.



YES



NO

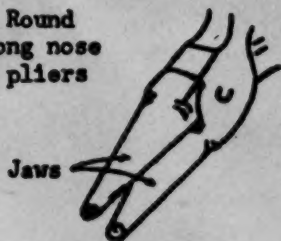
Check (✓) the true statement(s) below.

- ☐ 1. Combination pliers can be adjusted to fit various size objects.
- ☐ 2. Combination pliers may be used to loosen a nut, provided you are careful.
- ☐ 3. Plier jaw serrations are sharp, and may damage material on which they are used.

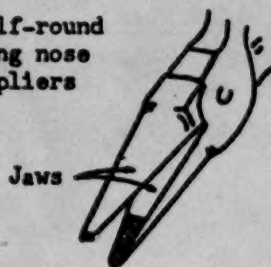


The pliers shown above are called chain long nose pliers. They are commonly referred to as needle-nose pliers. These pliers are used to hold small parts; reach into spots where the hand can't get; make fine adjustments; and to form loops in electrical wire. The pliers may have various lengths of jaws and the jaws may be either round or half-round as shown in the drawings.

Round
long nose
pliers



Half-round
long nose
pliers



Check (✓) the true statement(s) below.

- ___ 1. Needle-nose pliers have a jaw that forms to a point.
- ___ 2. All long-nose pliers have half-round jaws.
- ___ 3. Needle-nose pliers have slip-joints for size adjustments.
- ___ 4. Long-nose pliers are frequently used to form loops in electrical wire.

Answers to Frame 32: 1. ✓ 2. 3. ✓



A pair of duckbill pliers are shown above. They are used almost exclusively when you are working with safety wire. The pliers have jaws that are long and flat, as shown in the drawing below.



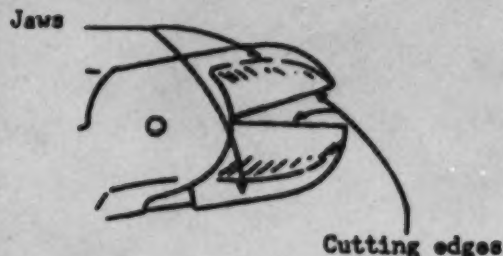
Check (✓) the true statement(s) below.

- ☐ 1. Duckbill pliers have round jaws.
- ☐ 2. Duckbill pliers have a squared jaw tip.
- ☐ 3. Duckbill pliers have the same jaws as needle-nose pliers.
- ☐ 4. Duckbill pliers are commonly used when working with safety wire.

Answers to Frame 33: 1. ☒ 2. ☐ 3. ☐ 4. ☒



The pliers shown above are diagonal cutting pliers or more commonly known as "dykes". The jaws have cutting edges used to cut safety wire, small electrical conductors or to remove cotter pins.

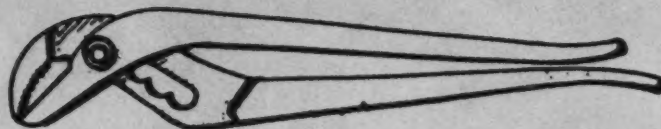


Diagonal cutters are only used to cut small size wire. These pliers can be easily damaged and should not be used to cut nails or similar objects. The wire to be cut should be placed as close to the pivot of the cutting jaws as possible and not at the points. This reduces the tendency to spring the jaws apart. Once the jaws are spread apart it is hard to cut small-sized wire. When using diagonal cutters, the inside of the cutting jaws should be pointed away from the user's face to prevent injury from flying clippings.

Check (✓) the true statement(s) below.

- ___ 1. Diagonal cutting pliers are also referred to as dykes.
- ___ 2. When using diagonal cutters, cut with the tip or point of the jaws.
- ___ 3. A common hazard is flying objects when using diagonal cutters incorrectly.
- ___ 4. Duckbill pliers and diagonal cutting pliers are commonly used when working with safety wire.
- ___ 5. Diagonal cutting pliers are used to cut small wires.

Answers to Frame 34: 1. ___ 2. ✓ 3. ___ 4. ✓



The pliers shown above are technically known as water pump packing nut pliers. They were given this name because of the purpose they were first designed to serve; tightening the nut compressing the packing material around the water pump drive shaft on very early model cars. Now we call them just water pump pliers.

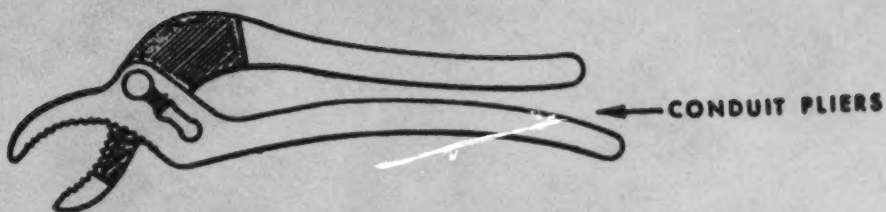
They are adjustable so as to grip large or small objects. Their long handles make possible a very strong grip. Their straight jaws give only two points of contact when used on large round objects. Because of this, they are likely to slip.

The slip joint feature of the water pump pliers makes them adjustable, so that different sizes of materials can be handled with them.

Check (✓) the true statement(s) below.

- ☐ 1. Water pump pliers are adjustable in size.
- ☐ 2. Water pump pliers grip large objects firmly because the jaw teeth provide complete contact around the object to be gripped.
- ☐ 3. The long handles on the water pump pliers allow for a more powerful grip.

Answers to Frame 35: 1. ☒ 2. ☐ 3. ☒ 4. ☒ 5. ☒



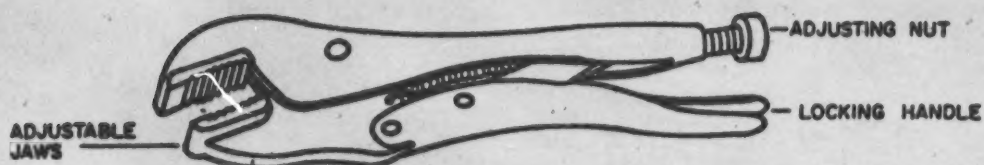
The pliers shown above are known as conduit pliers. Sometimes, they call them cannon plug pliers. If you compare the water pump pliers with the conduit pliers, they are almost the same. There are two main differences. The conduit pliers allow for a much larger grip. See how the jaws are curved. Also, the teeth of the jaws will grip the object firmly. See how the jaw teeth go all the way to the pivot point of the jaw. The teeth of the conduit pliers thus give contact all the way around the object to be gripped. Conduit pliers are used to loosen or tighten electrical conduit nuts or connections and cannon plugs.

Check (✓) the true statement(s) below.

- ___ 1. Conduit pliers have a slip joint.
- ___ 2. Conduit pliers allow for a large grip.
- ___ 3. Conduit pliers are identical to water pump pliers.
- ___ 4. Conduit pliers have teeth around the complete gripping surface of the jaws.

Answers to Frame 36: 1. ✓ 2. 3. ✓

The last pliers we want you to know is the wrench pliers, shown below.



This tool is commonly known as vise grips, for it is a combination of a wrench, a plier, and a vise. The adjustable jaws can be set by turning the adjusting nut at the end of one handle. When adjusted and the locking handle drawn into the locked position, it is like having the work locked in a vise.

You must take care not to use this tool on any machined surface that could be marred by the teeth of the vise jaws. The jaws can and will mark the surface of the material on which it is clamped.

This tool is handy for removing broken bolts when part of the bolt is still projecting.

1. Check (✓) the true statement(s) below.

- ☐ 1. Wrench pliers hold the work like vise grips.
- ☐ 2. Wrench pliers have a slip joint for size adjustment.
- ☐ 3. The locking handle must be drawn in the locked position for the work to be locked in the jaws.

Answers to Frame 37: 1. ☒ 2. ☒ 3. ☐ 4. ☒

Pliers are made in a wide range of sizes so not to overstrain and perhaps break something. Judgment must be used to pick pliers heavy and large enough for the job at hand. Do not use pliers as wrenches to tighten or loosen nuts. Pliers will damage the flats or round off the corners of nuts or bolts.

When cutting wire which is springy or under tension, caution must be used. The wire will try to whip. To stop this, one end of the wire should be held securely and your body turned or shielded from the loose end.

There is a common tendency among inexperienced mechanics to use pliers as all-purpose tools. The pliers are intended to aid the mechanic when installing and removing safety wire and cotter pins; to hold those materials which the hand alone is not strong enough to hold; and to hold materials which are hot, such as connections being soldered.

Check (✓) the true statement(s) below.

- ☐ 1. Pliers take the place of a wrench, if no wrench is handy.
- ☐ 2. Pliers can be considered as an all-purpose tool.
- ☐ 3. You must use judgement when selecting pliers.

Answers to Frame 38: 1. 1. ☒ 2. ☐ 3. ☒

Answer the following questions concerning pliers. After checking the answers at the end of the next frame, and if you missed any questions, review the appropriate frames.



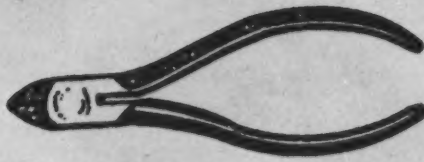
1. The above pliers are referred to as
 - a. water pump pliers.
 - b. conduit pliers.
 - c. combination pliers.
 - d. wrench pliers.



2. The above pliers are referred to as
 - a. duckbill pliers.
 - b. needle-nose pliers.
 - c. combination pliers.
 - d. conduit pliers.



3. The above pliers are referred to as
 - a. needle-nose pliers.
 - b. long-nose pliers.
 - c. combination pliers.
 - d. duckbill pliers.



4. The above pliers are often referred to as
- a. dykes.
 - b. combination pliers.
 - c. vise grips.
 - d. wrench pliers.



5. The above pliers are often referred to as
- a. conduit pliers.
 - b. cannon plug pliers.
 - c. water pump pliers.
 - d. wrench pliers.



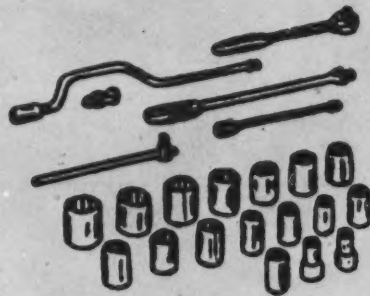
6. The above pliers are often referred to as
- a. wrench pliers.
 - b. combination pliers.
 - c. conduit pliers.
 - d. water pump pliers.
7. Combination pliers are commonly used to
- a. turn a nut.
 - b. cut a wire.
 - c. bend a piece of metal.
 - d. tighten a bolt.

8. To form loops in electrical wire, you would use
- a. duckbill pliers.
 - b. dykes.
 - c. wrench pliers.
 - d. needle-nose pliers.
9. Dykes are commonly used to
- a. bend a piece of metal.
 - b. cut a small wire.
 - c. turn a bolt.
 - d. hold a pipe.
10. To loosen a cannon plug, you would use
- a. water pump pliers.
 - b. conduit pliers.
 - c. wrench pliers.
 - d. combination pliers.

Answers to Frame 39: 1. ____ 2. ____ 3. ✓

Frame 41

Socket sets, as shown in the illustration, are made up of different combinations of handles, adapters, universal joints, and sockets. Where applicable and practical, a socket wrench is the best tool for removing nuts and bolts. They should be the mechanics first choice of wrenches. However, when reassembling parts of an aircraft or engine, the socket wrench should be used with caution.

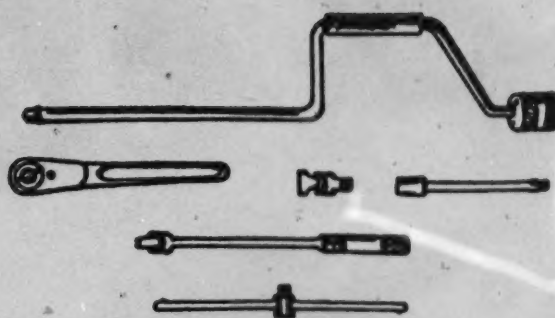


Answer each of the following statements as either true (T) or false (F).

- ___ 1. The socket set should be the mechanics first choice of wrenches.
- ___ 2. The socket set is made up of a variety of handles, extensions, universal joints, and a variety of sizes of sockets.
- ___ 3. The socket wrench is the best tool for removing nuts and bolts wherever practical.

Answers to Frame 40:

Question No	Answer	Review Frame	Question No	Answer	Review Frame
1. - - - - -	C - - - - -	32	6. - - - - -	A - - - - -	38
2. - - - - -	B - - - - -	33	7. - - - - -	C - - - - -	32
3. - - - - -	D - - - - -	34	8. - - - - -	D - - - - -	33
4. - - - - -	A - - - - -	35	9. - - - - -	B - - - - -	35
5. - - - - -	C - - - - -	36	10. - - - - -	B - - - - -	37



Where applicable and practical, the socket wrench set is the best tool for removing/installing nuts and bolts. However, the set should be used with caution. The available handles are interchangeable. They are made long enough to enable the mechanic to tighten the largest nuts or bolts without undue strain. If a long handle is used while turning a small nut or bolt, there is the possibility that enough twisting force (torque) will be exerted to strip the threads or pull the bolt in two. However, if the user holds the handle near the socket, instead of at the end of the handle, a long handle may be used satisfactorily.

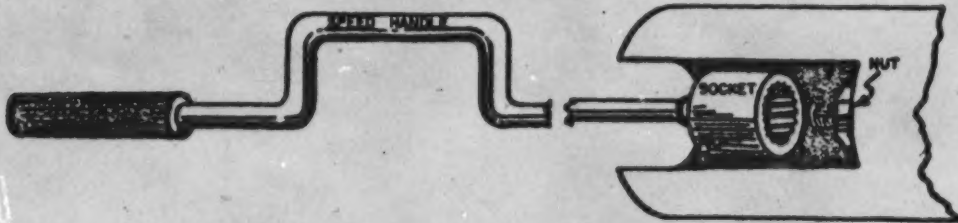
Some of the more commonly used accessories and handles for use with the socket wrench set are shown in the illustration above. Our experience has lead us to conclude that everybody needs to have a few words of explanation concerning the purpose, care, and use of some or all of these tools.

Check (✓) the correct statement(s) below.

- ☐ 1. Socket wrench handles are interchangeable.
- ☐ 2. The larger the handle, the more torque can be obtained.

Answers to Frame 41: 1. T 2. T 3. T

Sockets are used with a variety of handles. It is this variety that makes sockets the first choice of wrenches. If the work area has plenty of room or "swing space" the speed handle should be used to remove nuts or bolts quickly. The speed handle is held with one hand and the crank is held with the other hand. The long neck of the speed handle allows access to recessed nuts or bolts.

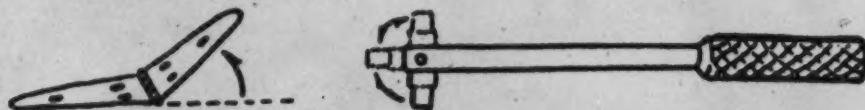


Answer the following statements as either true (T) or false (F).

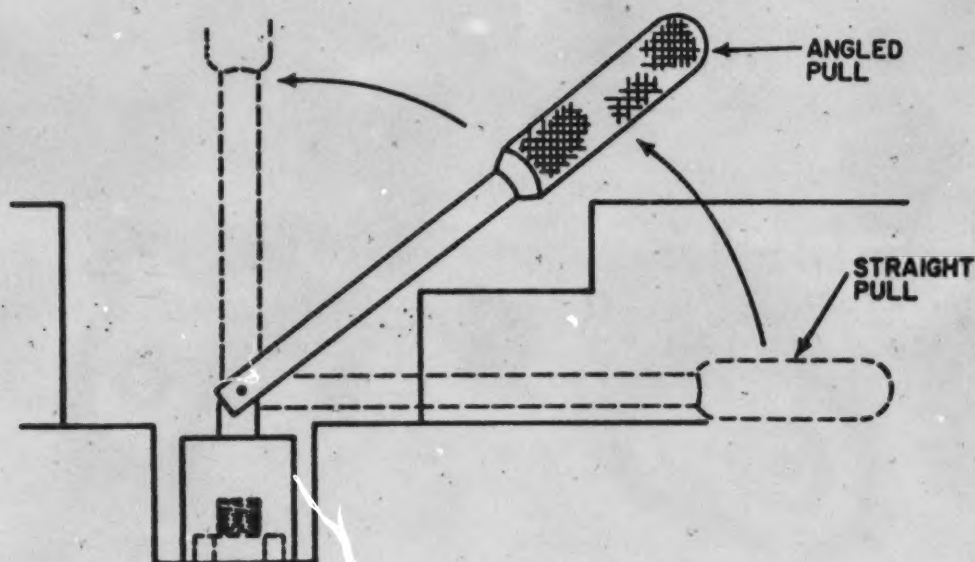
- ___ 1. The speed handle is used where the turning radius is limited.
- ___ 2. Nuts and bolts can be removed quickly with a speed handle.

Answers to Frame 42: 1. ✓ 2. ✓

Sometimes a lot of leverage is required to move a stubborn nut. The hinge handle can provide this leverage. This handle is so named because it is designed like a door hinge.



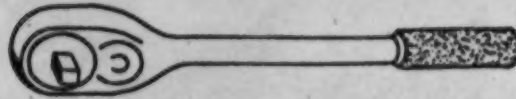
The hinge handle is the strongest handle in the toolbox. Because of this, it is used to break loose stubborn nuts and bolts. To loosen a nut, the handle can be used at right angles to the socket for a straight pull. This is shown in the figure below. If this is not possible, an angled pull may be used. After the nut is loosened, the handle can be moved on its hinge to the vertical position and twisted by the fingers to remove the nut.



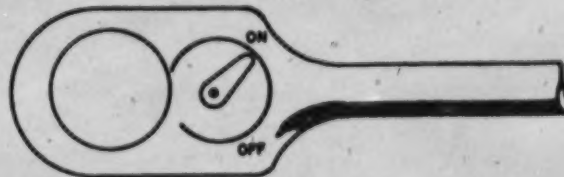
Answer each of the following statements as either true (T) or false (F).

- ___ 1. The hinge handle can be used for a straight (90 degree) pull if desired.
- ___ 2. The hinge handle will provide any angle of pull desired.
- ___ 3. Tight or "stubborn" nuts or bolts should be loosened with the hinge handle.

Answers to Frame 43: 1. F 2. T



One of the most useful handles is called a ratchet handle. (See above figure). This handle can be used to either tighten (put on) a nut, or loosen (take off) a nut. The figure below shows a ratchet handle set to tighten (put on) a nut. Many ratchet handles don't have the direction of the turn marked. These handles require a check to see in which direction (way) they are set to turn. By grasping the handle in one hand and the drive in the other, you can quickly determine which way the ratchet will turn or drive. This handle allows you to tighten or loosen a nut in a limited space without having to remove and reposition the socket on the nut. The handle slips (ratchets) one way, but will not slip the other way. To change the setting of the ratchet, merely move the control lever to its other position.



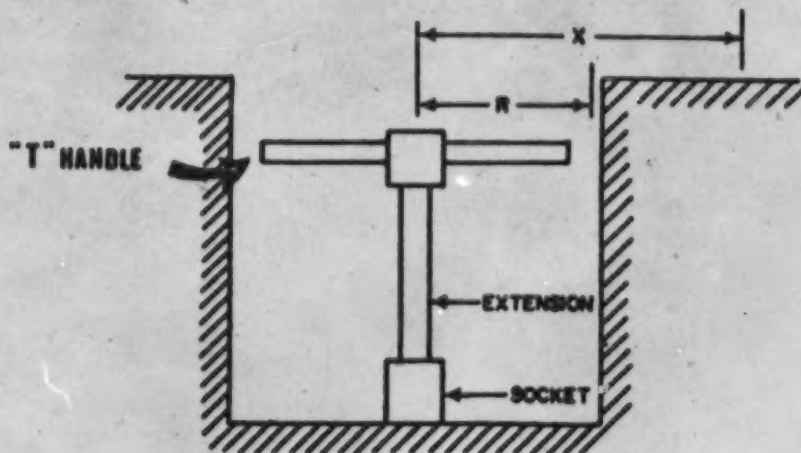
Never use a ratchet handle to break nuts or bolts loose. Using a solid handle or a box-end wrench will avoid damaging the ratchet handle.

Answer the following statements as either true (T) or false (F).

- ___ 1. The ratchet handle drives in one direction and slips in the other.
- ___ 2. When you can't get a straight pull on a nut, the ratchet handle will permit an angled pull.
- ___ 3. The ratchet handle can be operated without having to raise the socket off the nut for another "bite".

Answers to Frame 44: 1. T 2. T 3. T

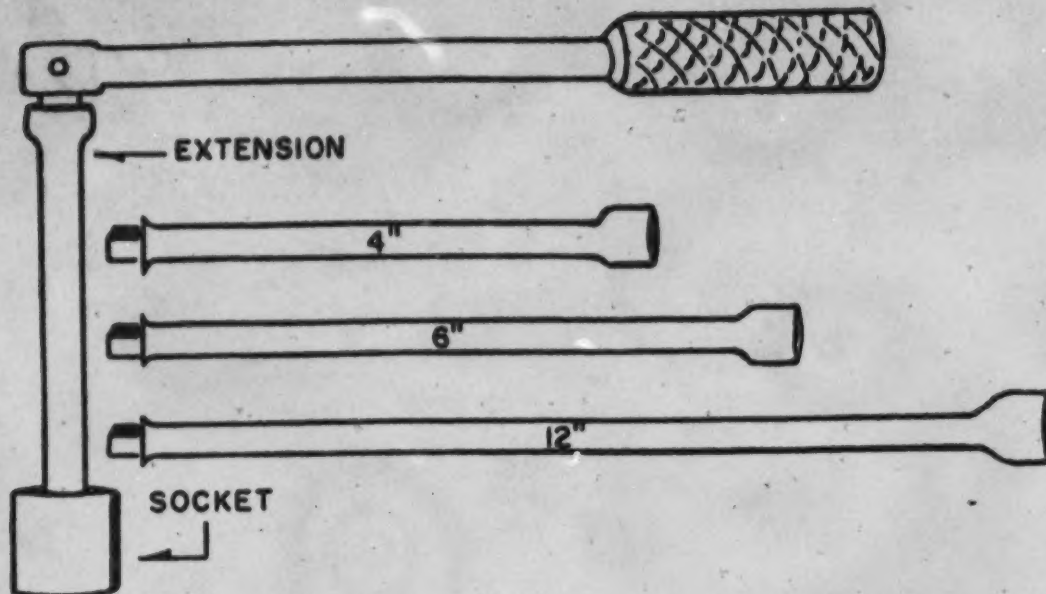
The T-handle is yet another type of handle used for driving sockets. The "T" makes it possible to put on the same force with both hands because the drive is in the center. Another advantage is that the turning radius is smaller than that needed with other handles, as shown in the illustration below. "R" shows the radius for the T-handle. "X" shows the radius needed for another type of handle.



Check (✓) the correct statement(s) below.

- ___ 1. Both hands can be used to apply equal force to the "T" handle.
- ___ 2. A large turning radius is required to use the "T" handle.
- ___ 3. When you use a socket you should use a hinge or "T" handle to loosen a "tight" nut.

Answers to Frame 45: 1. T 2. F 3. T



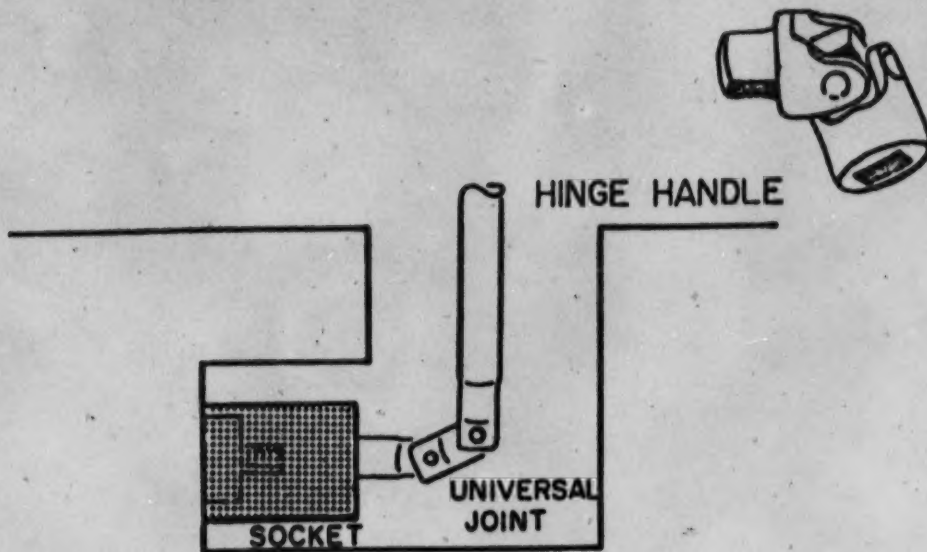
An "extension" is used to make something longer. If the socket handle that is used is not long enough to reach to the nut or bolt, an extension bar is put between the socket and its driving handle. Extensions are made in different lengths. We even have flexible extensions that further increase the useability of the socket wrench set.

Check (✓) the correct statement(s) below.

- ___ 1. The socket extension should always be used with the ratchet handle.
- ___ 2. An extension is used between the socket and the socket handle to reach nuts and bolts at various lengths.

Answers to Frame 46: 1. ✓ 2. 3. ✓

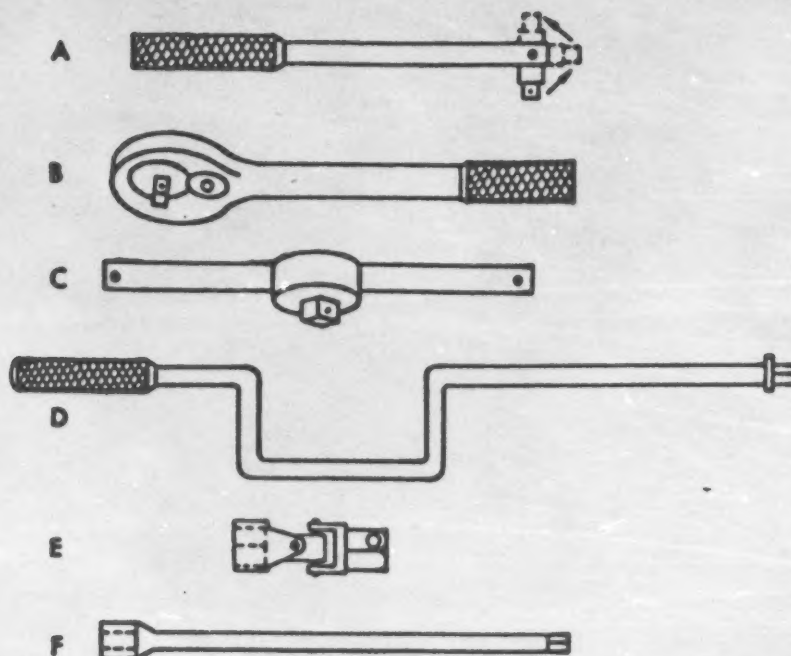
Universal means "all". With the universal joint, you can apply force in all directions. Since the universal joint is intended to be used between the socket and the socket handle, it has a male end and a female end. To turn a nut located in a hard-to-get-at place, you would use a universal joint as illustrated below.



Check (✓) the correct statement(s) below.

- ___ 1. Universal joints permit work where a straight wrench cannot be used.
- ___ 2. Universal joints have two male ends.
- ___ 3. Universal joints can apply force in all directions.

Answers to Frame 47: 1. ___ 2. ✓



1. Identify the above tools by writing their respective letters next to their nomenclature in the space provided.

- ___ 1. Ratchet handle
- ___ 2. Extension
- ___ 3. Speed handle
- ___ 4. "T" handle
- ___ 5. Hinge handle
- ___ 6. Universal joint

1911

Frame 49 Continued

2. Match each tool in column B with the proper use in column A.

Column A	Column B
___ 1. When the fast removal or replacement of nuts and bolts is required, and the swing arc is not limited.	A. T-handle
___ 2. For breaking nuts and bolts loose and to permit the freedom of any angle of pull desired.	B. Ratchet handle
___ 3. To tighten or loosen a nut, without having to remove and reposition the socket on the nut.	C. Speed handle
___ 4. When the turning radius is small or when a nut or bolt must be reached through a bulkhead.	D. Hinge handle
___ 5. Used if the socket handle drive isn't long enough or if the working area restricts the movement of tools.	E. Socket
___ 6. Used between the socket and the socket handle, to reach nuts and bolts at various angles.	F. Extension
	G. Universal joint
	H. Adapter

Answers to Frame 48: 1. ✓ 2. 3. ✓

Your toolkit will have several sockets to fit various sizes of nuts and handles. The first choice of experienced mechanics, when faced with the tightening or loosening of nuts and bolts, is the socket wrench. One reason for his choice is that sockets have more contact area and are less likely to slip. Most sockets in use in the Air Force have 12 gripping points. Repositioning of the socket for another turn is easy since the socket will fit on a nut or bolt in many different positions.

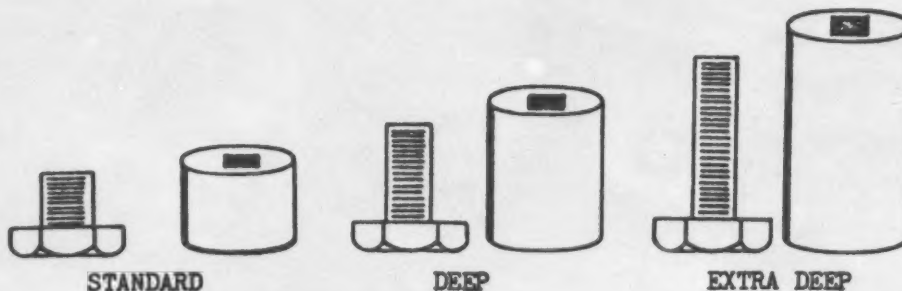


Sockets are not adjustable. They come in sets and each individual socket will fit only one size nut or bolt. The size nut or bolt head a socket will fit is plainly stamped into the side of each socket. The illustration above shows a socket that will fit a 9/16 inch bolt or nut head.



The square opening in the head of a socket, where the driving handle is attached, is called the female drive, illustration above. Sockets are not only sized according to the size nut or bolt they will fit, but also by the size of the drive that is used to turn them. Standard drives in common use are 1/4", 3/8", and 1/2".

Another thing to be considered when sizing sockets is the depth. In order to reach a nut turned way down on a long bolt, the socket would have to have considerable depth. Sockets are further classified as standard (shallow), deep, and extra deep.



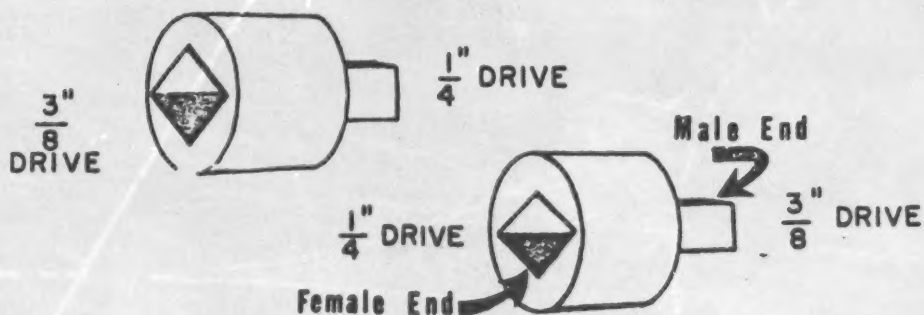
Check (✓) the true statement(s) below.

- ___ 1. The socket-drive hole (female drive) must be the same size as the square drive on the wrench handle.
- ___ 2. The number stamped on the socket refers to the size of the drive.
- ___ 3. The female drive of a socket must fit the nut or bolt to be removed.
- ___ 4. When selecting a socket, one must consider the size of the nut or bolt, the size of the drive, and the depth of the socket.
- ___ 5. The number stamped on the socket refers to the size of the bolt to be worked on.
- ___ 6. The standard socket refers to the shallowest socket.

Answers to Frame 49: 1. 1. B 2. F 3. D 4. C 5. A 6. E

2. 1. C 2. D 3. B 4. A 5. F 6. G

Sometimes you will have a socket with a $\frac{1}{4}$ " drive and a handle with a $\frac{3}{8}$ " drive. These can be adapted to each other by use of an adapter. The male and female drives of the adapters are of different sizes. The addition of this device to the socket wrench set makes it possible to reduce the total number of tools required to be carried to a job and provides greater useability of those required on the job.

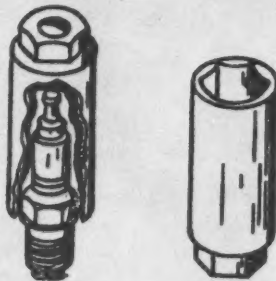


Check (☒) the correct statement(s) below.

- ☐ 1. One end of the adapter fits the bolt or nut to be removed or installed.
- ☐ 2. The female part of the adapter fits the handle.
- ☐ 3. The male part of the adapter fits the socket.
- ☐ 4. Both ends of the adapter are the same size.

Answers to Frame 50: 1. ☒ 2. ☐ 3. ☐ 4. ☒ 5. ☒ 6. ☒

A socket is available to ease the installation or removal of spark plugs. The spark plug holding socket has six points that grip the spark plug closely. This tight grip prevents the socket from dropping and breaking the porcelain on the spark plug during its removal or installation.



Check (✓) the correct statement(s) below.

- ☐ 1. The spark plug holding socket has six points.
- ☐ 2. The spark plug holding socket has a holding device built into it to grip and hold the spark plug in the socket.

Answers to Frame 51: 1. ☐ 2. ☒ 3. ☒ 4. ☐

3/8" FEMALE
DRIVE

(A)

1/2" FEMALE
DRIVE

(B)



(C)

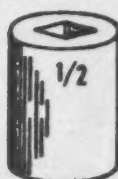
NOTE:
THIS SOCKET HAS A HOLDING
DEVICE BUILT INTO IT

(D)



(E)

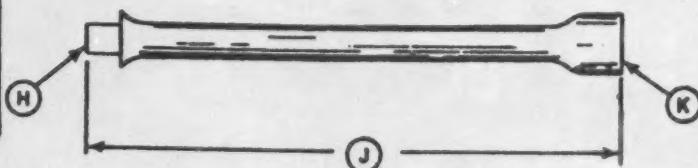
1/4" DRIVE



(F)



(G)



1. Match the items illustrated above with the statements listed below.

___ 1. Spark plug holding socket

___ 2. Six point socket

___ 3. 12 point socket

___ 4. Male drive end

___ 5. Female drive end

___ 6. Extension length

___ 7. Standard socket

___ 8. Deep socket

___ 9. 1/2" square drive
socket, 13/16" size___ 10. 3/8" square drive
socket, 3/4" size___ 11. 1/4" square drive
socket, 1/2" size___ 12. The socket required
to turn a 3/4" nut
with a 3/8" male
drive handle

1917

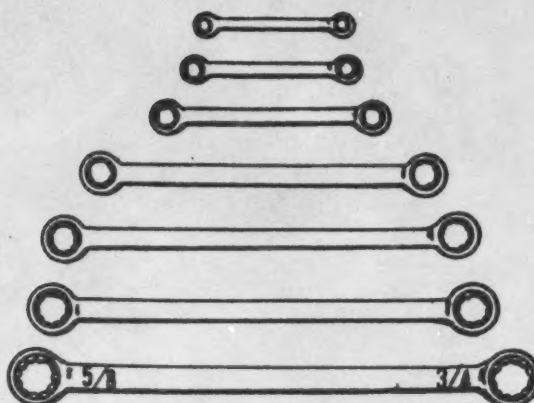
Frame 53 Continued

2. Answer each of the following statements as either true (T) or false (F).

- ☐ 1. The size of socket drives (handles) is determined by the dimension of the square end of the drive and the square hole in the socket.
- ☐ 2. Due to the various choices of handles, and the variety of drives and adapters, the socket wrench can be used for many different jobs.
- ☐ 3. The spark plug holding socket has a holding device built into it to grip and hold the spark plug in the socket so that it will not fall out during removal or installation.
- ☐ 4. The purpose of a wrench is to tighten or loosen nuts and bolts.
- ☐ 5. An adapter has different size ends.

Walk over to the handtool trainer and look at the many handles, sockets, and attachments available.

Answers to Frame 52: 1. ✓ 2. ✓



This is a set of box-end wrenches. A box-end wrench is essentially a bar with a socket on each end.

These wrenches are used for general work and they are well suited for operation in close quarters.

Their heads are small and yet they completely surround the object being worked on. They can be used on nuts which cannot be gripped by other types of wrenches. Most box-end wrenches have twelve points and almost all nuts and bolts have six sides. Therefore, as little as one-twelfth of one turn can be taken each time the wrench is shifted.



Box-end wrenches may be further identified as being "offset". This means that the head is offset (bent off to one side) by an angle of 15 degrees from the handle. This is to provide clearance for the user's hand and prevent "barking" of his knuckles.

Check (✓) the correct statement(s) below.

- ☐ 1. A box-end wrench has a socket on each end.
- ☐ 2. Each end of the box-end wrench is a different size.
- ☐ 3. All box-end wrenches are straight.

Answers to Frame 53: 1. 1. C 2. D 3. E 4. H 5. K 6. J 7. A, B, or F
8. G 9. B 10. A 11. F 12. A

2. 1. T 2. T 3. T 4. T 5. T



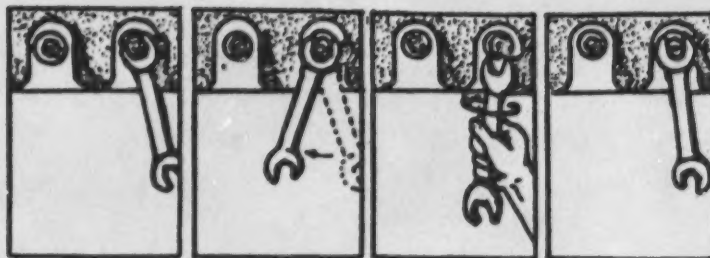
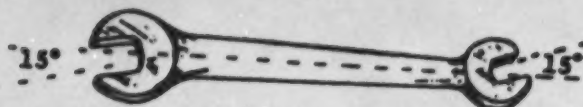
Nut and boltheads are measured and their sizes expressed as the distance between two opposite "flats". See the figure above.

The length of box-end wrenches is proportional to the size of the nut it fits. The sizes of box-end wrenches are stamped into the metal near each end. The proportional sizing of box-end wrenches makes them good tools to use for the final setting of nuts or bolts. The mechanic is not so apt to overtighten the nut so that he strips the threads or pulls the bolt apart.

Check (✓) the correct statement(s)* below.

- ☐ 1. Nut and bolthead sizes are determined by measuring from corner to corner.
- ☐ 2. Small box-end wrenches have large handles.
- ☐ 3. The size of the box-end wrench is stamped in the metal, near the end.
- ☐ 4. The smaller the box-end wrench socket, the smaller the handle.
- ☐ 5. The longer the box-end wrench handle the more torque can be applied.

Answers to Frame 54: 1. ☒ 2. ☒ 3. ☐



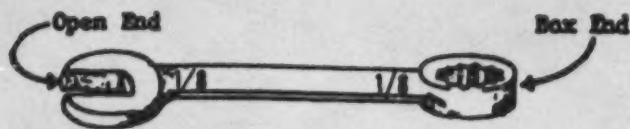
Open-end wrenches are open at the ends. They can be used on tubing nuts and in other places where it would be impossible to use a box-end or other type of wrench. The open-end wrench should be used only when conditions make it impossible to use the box-end wrench. The box-end wrench bears against the nut or bolt head on six points. However, the open-end wrench bears against the same nut or bolt head at only two points. This two point contact is apt to lead to rounding off the corners of the nuts or bolts on which the open-end wrench is used.

Open-end wrenches fit standard sized nuts and are light, strong, and convenient for working in limited space. The distance between jaws determines the size of the nut it will fit. Because the jaws are set at an angle, usually 15 degrees, it is easy to increase the swing of the handle by turning the wrench over. The length of the wrench varies according to the size of the opening, which is plainly stamped near each end of the wrench.

Check (✓) the correct statement(s) below.

- ___ 1. The open-end wrench is better than the box-end wrench when removing bolts.
- ___ 2. The jaws of an open-end wrench are usually set at a 15 degree angle.
- ___ 3. The length of the wrench varies according to the size of the opening.

Answers to Frame 55: 1. ___ 2. ___ 3. ✓ 4. ✓ 5. ✓



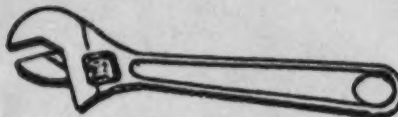
Combination wrenches are designed to provide a box-end on one end and the same size open-end on the other end.

The combination wrench is used to loosen and tighten nuts and bolts. The box-end is used to "break" the nuts and bolts free, then the open-end can be used to remove or replace the nuts and bolts more quickly.

Check (✓) the correct statement(s) below.

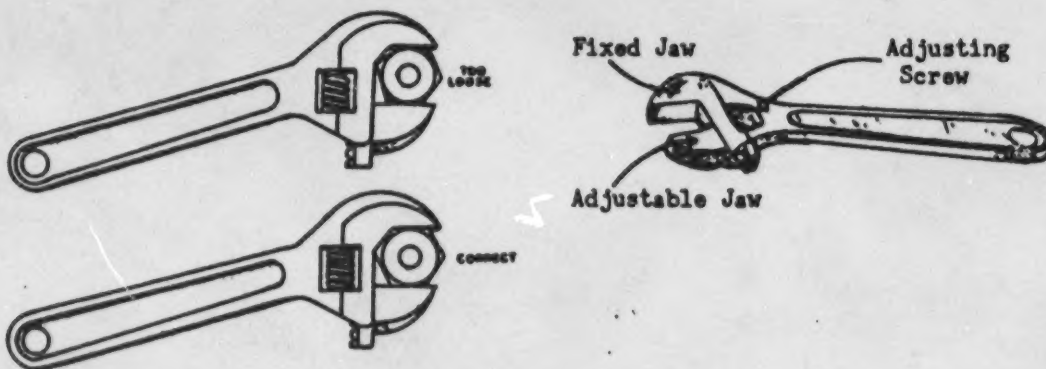
- ☐ 1. A combination wrench has the same size open-end as box-end on each side of the wrench.
- ☐ 2. The open-end of the combination wrench is set at a 15 degree angle.

Answers to Frame 56: 1. ☐ 2. ☒ 3. ☒



This is an open-end adjustable jaw wrench. It is made so its jaws can be opened or closed to fit the flats of the nut or bolthead. The face of each jaw is smooth. The size of the wrench is given in inches, which is the overall length of the tool.

The adjustable jaw wrench is the most commonly misused tool available to the mechanic. Normally, it should be used only when other wrenches are not available or do not fit the nuts or bolts to be worked on. For minor adjustments, where the torque required is not too great, this wrench works satisfactorily. Care should be exercised because this wrench is more apt to round off the corners than one which fits perfectly.



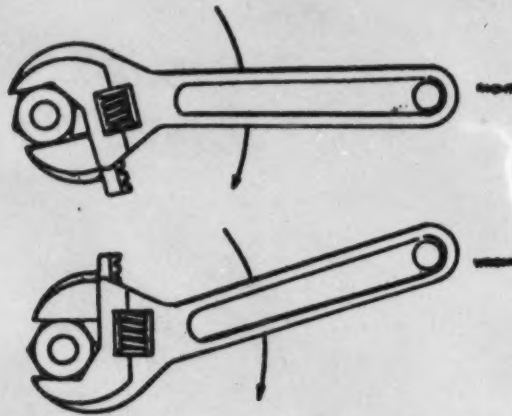
Shaking the wrench slightly, while it is being adjusted to the nut or bolt size, will aid in getting a more nearly perfect fit.

Check (✓) the correct statement(s) below.

- ___ 1. The correct way to determine the size of an adjustable jaw wrench is to measure the maximum jaw opening.
- ___ 2. Adjustable jaw wrenches should be used where the turning effort (torque) is not too great.
- ___ 3. Shaking the wrench, while making the size adjustment, aids in getting a better fit.

Answers to Frame 57: 1. ✓ 2. ✓

The adjustable jaw wrench should always be turned in the proper direction. All adjustable jaw wrenches should always be pulled so that the handle moves toward the adjustable jaw. If an adjustable jaw wrench is turned over and used so that the pressure is on the main jaw, it is very likely that the adjustable jaw will break.

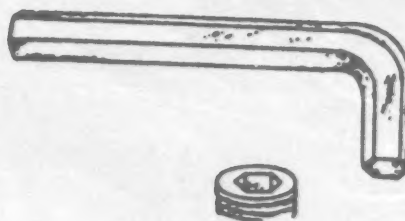


This tool is commonly known as the "knuckle buster" for it is prone to slip from the part being worked on. Always place the wrench in a position so that the pull on the handle tends to force the jaws further onto the nut. The most effective angle for this pulling is with the arm at right angles to the handle and the center line of the nut or bolt. This helps prevent wrench slippage.

Check (✓) the correct statement(s) below.

- ___ 1. The correct way to use an adjustable jaw is to push it toward the adjustable jaw.
- ___ 2. Incorrect use of the adjustable jaw wrench can cause slippage.
- ___ 3. Adjustable jaw wrenches should always be pulled so that the handle moves toward the adjustable jaw.

Answers to Frame 58: 1. ___ 2. ✓ 3. ✓



To the old-timer, the object shown above is known as an "Allen wrench". Technically, it is a "key, socket head screw".

Regardless of what it is called, the tool is a hexagonal steel bar with a 90 degree bend. The longer portion is normally considered to be the handle, although both ends are the same size and can be used interchangeably. The size of the tool is found by measuring the distance across the flat tip or end.

Whereas most wrenches fit outside of a nut or bolt, this key fits inside the head of a bolt or screw. These tools are used to turn screws and setscrews used to fasten pulleys to shafts where the head of a conventional screw would interfere with operation. This "working from the inside" feature has lead some people to call this tool an "internal wrenching" key.

Check (✓) the correct statement(s) below.

- ☐ 1. An "Allen wrench" is designed for internal wrenching bolts.
- ☐ 2. Only the short end of the key socket head screw is used to tighten setscrews.
- ☐ 3. The Allen wrench is six sided.

Answers to Frame 59: 1. ☐ 2. ☒ 3. ☒

1925

Frame 61

Never use a wrench as a hammer or crowbar.

Stop pulling on the nut as soon as it is turned down tight. If a definite tightness is specified, you will have to use a torque wrench to complete technical publications requirements.

Always think twice before pushing on a wrench. If you are standing on a wet surface there is the possibility that you may fall flat on your face. Ten chances to one you will find it safer to pull. If the wrench must be pushed, use the palm of your open hand so that your knuckles will not be mashed in case something does slip.

See that your footing is good before you pull. Get into the habit of figuring out what is going to happen when the wrench slips, the bolt breaks, or the threads strip. Particular care should be taken when working on a ladder, stand, or in any elevated position.

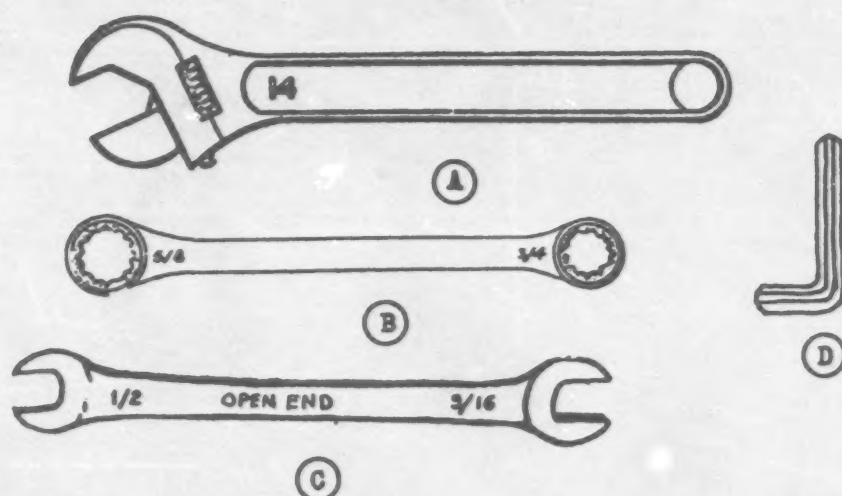
Never use a pipe or another wrench to extend the handle of a wrench in order to gain leverage. Something is bound to give - but maybe not what you expect.

Inspect all wrenches frequently for general condition, cleanliness, chips, cracks, etc. Avoid throwing wrenches or other tools into your toolbox.

Check (✓) the correct statement(s) below.

- ☐ 1. A wrench is a universal tool, it can be used as a substitute for many common handtools.
- ☐ 2. Never push a wrench.
- ☐ 3. A pipe may be used to extend the length of a wrench.

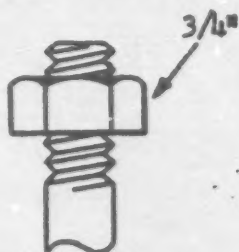
Answers to Frame 60: 1. ☒ 2. ☐ 3. ☒



1. Study the sizes of the wrenches shown above: THEN place the letter of the proper wrench to be used for each nut or bolt in the spaces provided below.



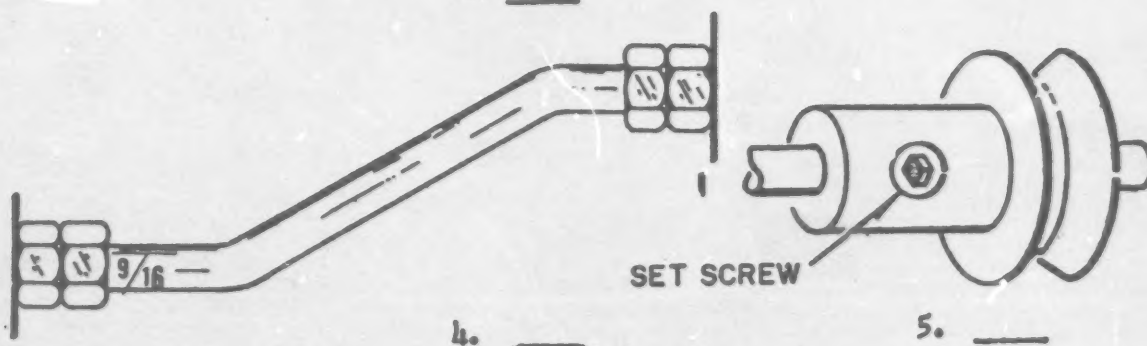
1. _____



2. _____



3. _____



4. _____

5. _____

1927

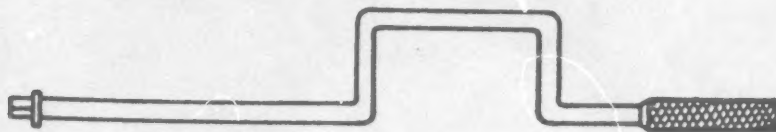
Frame 62 Continued

2. The uses of wrenches are listed in column A, the types of wrenches are listed in column B. Match each wrench in column B with its proper use in column A.

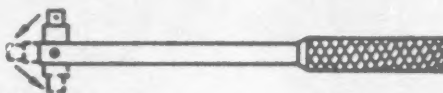
Column A	Column B
___ 1. Used on internal wrenching hexagon bolts, plugs, and setscrews.	A. Open-end wrench.
___ 2. Must be used on gas and oil line fittings.	B. Adjustable jaw wrench.
___ 3. Used in hard to reach places. It completely surrounds the bolthead or nut to be turned.	C. Socket screw wrench.
___ 4. Will fit any bolt or nut within its range and works satisfactorily for adjustments, or where the turning effort (torque) is not too great.	D. Box-end wrench.

Answers to Frame 61: 1. ___ 2. ✓ 3. ___

Answer the following questions concerning wrenches. If you missed any questions, review the appropriate frames.



1. The above tool is called a
 - a. hinge handle.
 - b. ratchet handle.
 - c. "T" handle.
 - d. speed handle.



2. The above tool is called a(n)
 - a. hinge handle.
 - b. speed handle.
 - c. ratchet handle.
 - d. extension.



3. The above tool is called a(n)
 - a. hinge handle.
 - b. extension.
 - c. universal joint.
 - d. socket.



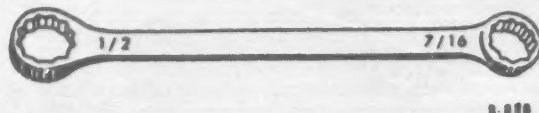
4. The above tool is called a(n)
 - a. extension.
 - b. swivel socket.
 - c. universal joint.
 - d. shallow socket.



5. The above socket will fit a
- a. 3/4" bolthead.
 - b. 3/4" drive.
 - c. any size bolthead.
 - d. 3/4" drive and 3/4" bolthead.



6. The above tool is called a(n)
- a. universal joint.
 - b. adapter.
 - c. socket.
 - d. adjustable wrench.



7. The above tool is called a(n)
- a. open-end wrench.
 - b. box-end wrench.
 - c. combination wrench.
 - d. adjustable wrench.



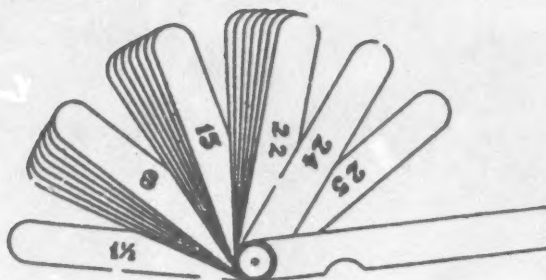
8. The above tool is sometimes called a(n)
- a. screwdriver.
 - b. socket wrench.
 - c. Allen wrench.
 - d. external wrench.

9. The best tools for removing nuts and bolts wherever practical are
 - a. adjustable jaw wrenches.
 - b. combination pliers.
 - c. socket wrenches.
 - d. open-end wrenches.
10. Speed handles are used where
 - a. the turning radius is limited.
 - b. speed is required.
 - c. an angle pull is required.
 - d. tight nuts must first be broken loose.
11. Which of the following socket handles drives in one direction and slips in the other direction?
 - a. Hinge handle.
 - b. Speed handle.
 - c. Ratchet handle.
 - d. "T" handle.
12. Which socket handle can be operated without having to raise the socket off the nut for another "bite"?
 - a. Hinge handle.
 - b. Ratchet handle.
 - c. Speed handle.
 - d. "T" handle.
13. To get to a nut located in a hard-to-get-at place, you would use a(n)
 - a. adapter.
 - b. universal joint.
 - c. "T" handle.
 - d. speed handle.
14. The socket-drive hole (female drive)
 - a. has its size stamped on the side of the socket.
 - b. fits any size socket handle.
 - c. must be the same size as the bolt.
 - d. is attached to the socket handle.

15. To reduce the total number of tools required to be carried to a job, it would be best to carry which of the following tools?
- a. Universal joint.
 - b. Speed handle.
 - c. Adapter.
 - d. Extension.
16. Which of the following tools is best suited to remove a nut?
- a. Box-end wrench.
 - b. Open-end wrench.
 - c. Adjustable jaw wrench.
 - d. Pliers.
17. Which of the following wrenches will yield the largest amount of torque?
- a. Short handled, open-end wrench.
 - b. Long handled, box-end wrench.
 - c. Adjustable jaw wrench.
 - d. Short handled, box-end wrench.
18. What is the correct way to use an adjustable jaw wrench?
- a. Push it toward the adjustable jaw.
 - b. Pull it toward the stationary jaw.
 - c. Pull it toward the adjustable jaw.
 - d. Push it toward the stationary jaw.

Answers to Frame 62: 1. D 2. B 3. A 4. C 5. D
2. 1. C 2. A 3. D 4. B

Section V



The thickness gauge consists of a set of leaves of hard steel. Each leaf is ground to a definite thickness, having one end of each leaf fastened into a protective case. A set usually consists of leaves ranging in size from fifteen ten-thousandths (0.0015) of an inch to twenty-five thousandths (0.025) of an inch.

Thickness gauges are used to measure the clearance between two parts. One leaf at a time is tried until the thickness leaf which will enter the opening is found. The clearance is determined by reading the thickness stamped on the particular leaf.

The leaf should always be wiped off before trying to insert it between two parts. The leaf should never be forced into an opening. Light pressure only should be applied. If the leaf is forced, it may spread the opening. This gives an inaccurate indication of size or there is danger of kinking the leaf and ruining it. Two leaves may be wiped clean and used together if one leaf of the proper thickness is not available.

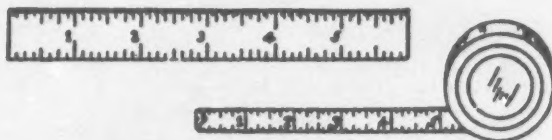
Check (✓) the correct statement(s) below.

- ___ 1. The thickness gauge is calibrated in thousandths of an inch.
- ___ 2. Thickness gauges are used to measure the clearance between two parts.
- ___ 3. Only one leaf of the thickness gauge can be used to measure the clearance.

Answers to Frame 63:

Question No	Answer	Review Frame	Question No	Answer	Review Frame
1. - - - - -	D - - - - -	43	10. - - - - -	B - - - - -	43
2. - - - - -	A - - - - -	44	11. - - - - -	C - - - - -	45
3. - - - - -	B - - - - -	47	12. - - - - -	B - - - - -	45
4. - - - - -	C - - - - -	48	13. - - - - -	B - - - - -	48
5. - - - - -	A - - - - -	50	14. - - - - -	D - - - - -	50
6. - - - - -	B - - - - -	51	15. - - - - -	C - - - - -	51
7. - - - - -	B - - - - -	54	16. - - - - -	A - - - - -	54
8. - - - - -	C - - - - -	60	17. - - - - -	B - - - - -	55
9. - - - - -	C - - - - -	41	18. - - - - -	C - - - - -	59

The work of a mechanic is no more accurate than the measurements he makes. It is important, therefore, that he learns to use and read measuring instruments correctly and accurately. There are many different types of measuring instruments; each type is best for a specific purpose. The most common unit of measurement with which you will work is the inch, which is further divided into fractions.



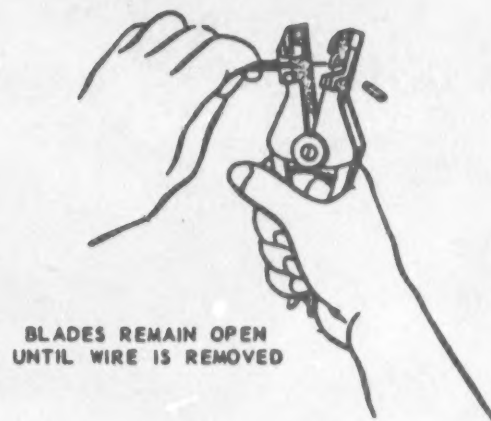
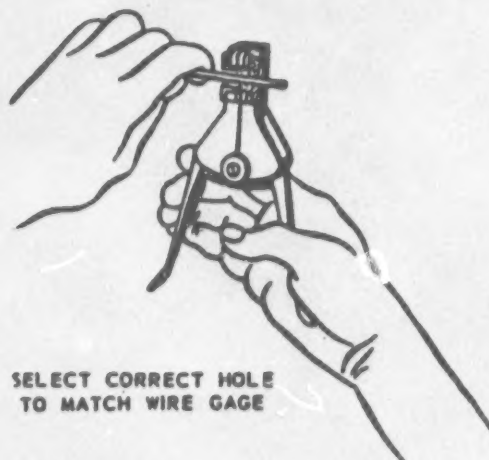
Rules are usually made of steel and they are available in 4, 6, or 12-inch lengths. The largest unit of measurement common to these rules is the inch. The inch may be divided into smaller fractions, such as $1/4$, $1/2$, $1/8$, $1/16$, $1/32$, and even $1/64$. Graduations of less than $1/64$ are not used because they are difficult to read.

Tapes are available in many kinds and lengths. The one commonly used by most mechanics is six feet in length and is made of flexible steel. It is coiled in a circular case. The tape may be easily drawn out of its case when needed, and pushed back into the case when not needed. Tapes are graduated, usually in sixteenths ($1/16$) or thirty-seconds ($1/32$) of an inch. Most tapes have a small lip on one end which prevents the end from slipping into the case when the tape is rolled up into the case. This lip also enables the user to line up the end of the tape more easily with the end of the piece being measured.

Check (✓) the correct statement(s) below.

- ___ 1. The smallest measurement on a rule is $1/32$ of an inch.
- ___ 2. Tapes are used when long distance measurements are required.
- ___ 3. To measure the diameter of a bolt, you would use a rule.
- ___ 4. To measure the length of a component, you would use a tape measure.

Answers to Frame 64: 1. ✓ 2. ✓ 3.



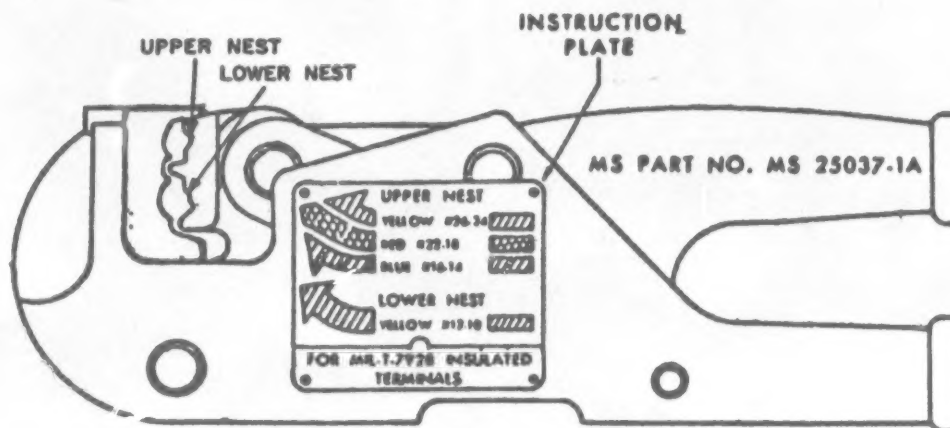
Wire strippers are used to take off insulation from the ends of electrical wires. Several holes corresponding to various wire sizes are in the cutting edge of the tool. Care must be taken to make sure that the correct hole is used for the wire being stripped. If the stripper hole is too small, some wire strands may be cut.

Check (✓) the true statement(s) below.

- ___ 1. There must be careful selection of the hole on the wire stripper for the wire size to be stripped.
- ___ 2. The stripper should cut completely through the insulation.
- ___ 3. A stripper is a handy tool for removing insulation from the center of a length of wire.

Answers to Frame 65: 1. ___ 2. ✓ 3. ✓ 4. ✓

The crimping tool, shown below, should be used for connecting (crimping) preinsulated terminals to conductors. Other crimping tools such as Stakon pliers should be used to crimp noninsulated terminals. The insulation on the terminals is color coded according to the size of the conductors to which they are to be joined. The instruction plate on the tool shows which of the nests should be used for the sizes of wire.

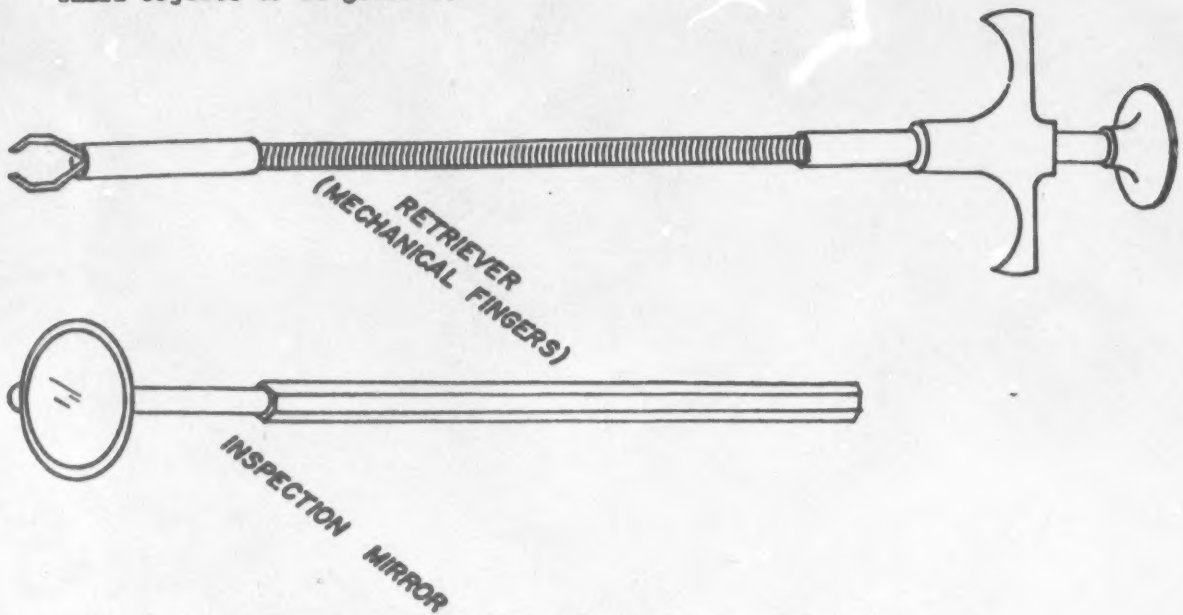


Check (✓) the true statement(s) below.

- ___ 1. Preinsulated terminals can be crimped to a conductor.
- ___ 2. Noninsulated terminals can be crimped to a conductor.
- ___ 3. The instruction plate on the crimper indicates the pressure needed to crimp terminals to wires.

Answers to Frame 66: 1. ✓ 2. ✓ 3. ___

The retriever, sometimes called "mechanical fingers," is used to pick up small objects that are located in inaccessible areas. By pushing down the button, the grip opens enabling small objects to be grabbed.



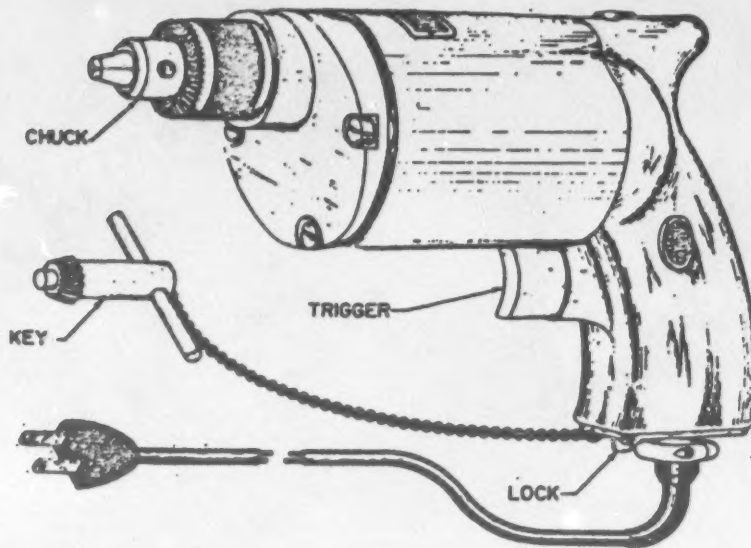
An inspection mirror can be used when the work being done is located in such a position that it is out of view. A noninsulated mirror should not be used around live electrical circuits.

1. Check (✓) the correct statement(s) below:

- ___ 1. The retriever can be used to pick up fallen screws in hard-to-get-at places.
- ___ 2. An insulated inspection mirror must be used on all equipment.

Answers to Frame 67: 1. ✓ 2. ✓ 3.

One of the most useful tools available to the mechanic is the electric drill. The principal use of the electric drill is for boring or drilling holes in metal. Drills commonly used in the shop are of the 1/4-inch, 3/8-inch, or 1/2-inch capacity. It is never advisable to exceed the rated capacity of an electric drill. Such a practice usually results in burning up the drill motor. For shop use, hardened steel drill bits are used with the electric drill. As you can see from the picture below, the main parts of the portable electric drill are the motor, chuck, handle, trigger, trigger lock, and chuck key.

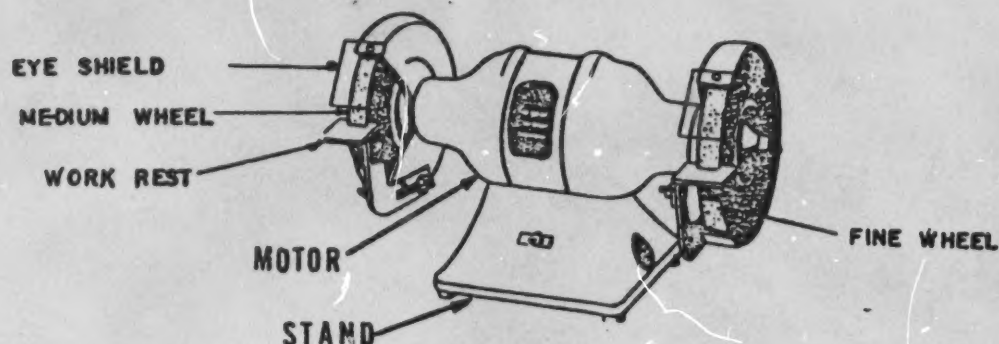


Circle the letter of the correct statement below.

- a. The best tool for drilling holes in metal is the electric drill.
- b. The capacity of an electric drill should never be exceeded.
- c. Hardened steel drill bits are best for use with the electric drill.
- d. All of the above statements are true.

Answers to Frame 68: 1. 1. ✓ 2.

Another power tool found in most shops is the bench grinder. A typical bench grinder is shown in the illustration below. Note that the main parts of the bench grinder are the stand, motor, grinding wheels, work rest, and eye shield. The grinding wheels should always be checked for cracks before starting the motor.



The bench grinder works best at maximum RPM. Too much pressure on the grinding wheel will cause the motor to overheat and the metal being sharpened to burn. The grinding action is the result of friction between the wheel and the metal; so the faster the rotation of the grinding wheel, the greater the friction.

Circle the letter in front of the correct statement below.

- a. Pressing hard on the grinding wheel increases its efficiency.
- b. Too much pressure on the wheel will cause the metal to burn.
- c. If the motor turns too fast, it will overheat.
- d. Friction helps cool the metal.

Answer to Frame 69: d

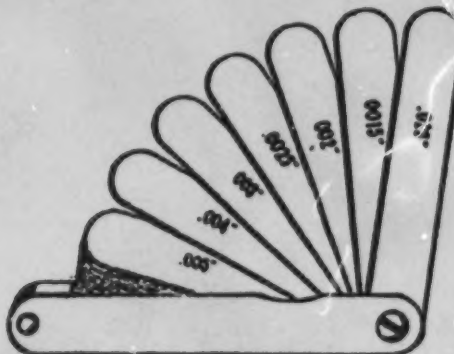
The bench grinder usually has two stones or wheels; one made of fine grit and the other of coarse grit. The grit is held together by a strong adhesive. An electric motor (usually rated at 1/2 horsepower) turns the stones at a high rate of speed. The material to be sharpened, smoothed, or reduced in size is held on the tool rest and pressed against the rotating stone.

Circle the letter in front of the correct statement(s) below.

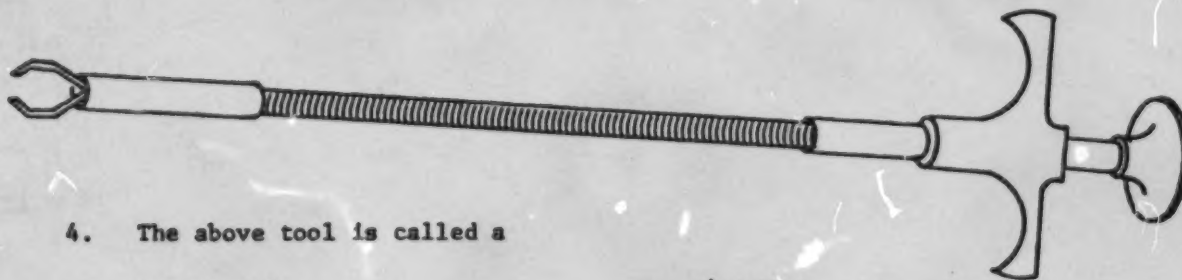
- a. Grinding wheels are cut out of solid stone.
- b. Bench grinders are used to sharpen chisels, punches, and drill bits.
- c. The material to be "ground" is pressed against the rotating wheel.
- d. The stones are turned at a high rate of speed.

Answer to Frame 70: b

Answer the following questions concerning tools. If you missed any questions, review the appropriate frames.



1. The above tool is called a
 - a. rule.
 - b. tape measure.
 - c. thickness gage.
 - d. depth gage.
2. The tool best suited to measure the diameter of a bolt is called a
 - a. rule.
 - b. tape measure.
 - c. thickness gage.
 - d. yard stick.
3. To remove the insulation from a wire you would best use a
 - a. crimping tool.
 - b. knife.
 - c. wire stripper.
 - d. diagonal cutting pliers.



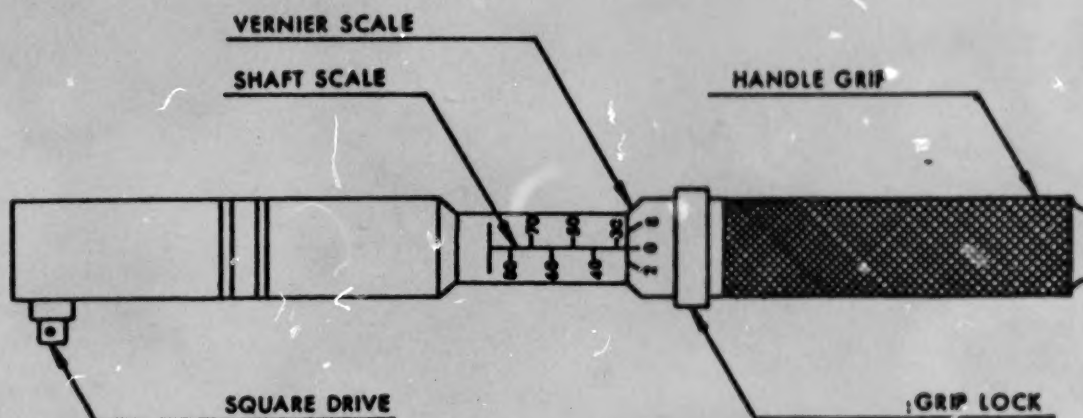
4. The above tool is called a
 - a. magnet.
 - b. retriever.
 - c. mirror.
 - d. long stem screwdriver.

5. The drill bit on an electric drill is inserted in the
- a. mouth.
 - b. chuck.
 - c. nose.
 - d. lock.
6. A bench grinder operates most efficiently
- a. at maximum RPM.
 - b. at slow speeds.
 - c. without a tool rest.
 - d. when pressing hard on the grinding wheel.

Check (✓) your answers at the end of frame 85. If you missed any of the questions, review the appropriate frames before going on to the next frame.

Answers to Frame 71: b c d

A torque wrench is used to measure how much torque (twisting force) is applied to a nut when it is put on a bolt. Some wrenches are made to measure torque in inch-pounds, others in foot-pounds. The type of torque wrench most used in the Air Force is the "breakaway" type. These are sometimes called the Automatic-Release-Torque wrench. This is the only type of wrench we are authorized to use on nuts, bolts, etc., which we put on a plane. The breakaway torque wrench (see sketch below) has a square drive, shaft scale, vernier scale, grip on handle and a grip lock.



Check the correct statement(s) below.

- ☐ 1. Torque wrenches measure torque in foot-pounds only.
- ☐ 2. The "breakaway" type torque wrench is the most commonly used torque wrench in the Air Force.
- ☐ 3. The Vernier scale and the grip lock are attached to the handle.
- ☐ 4. Common aircraft hardware should NOT be torque with a "breakaway" type torque wrench.

Some types of torque wrenches are the screwdriver type, the flexible beam type and the dial which are NOT authorized for use in tightening common aircraft hardware. In some specific applications of checking torque, an aircraft manual or equipment maintenance manual may require one of the above mentioned wrenches to be used.

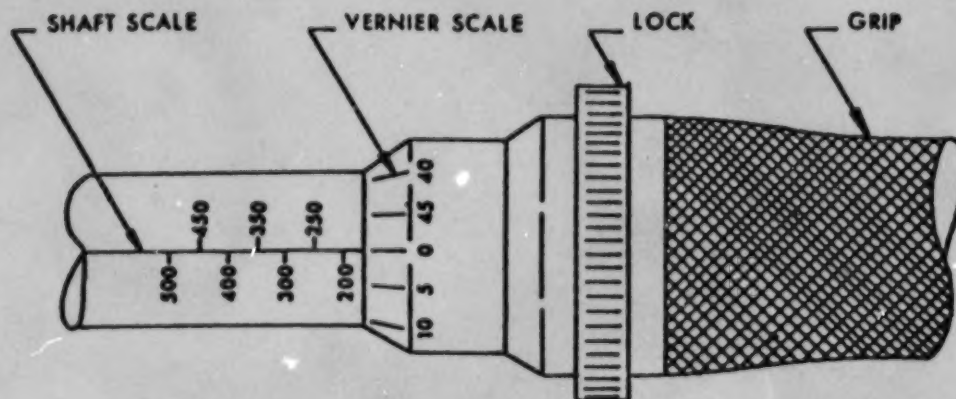
Note: The term "TORQUE WRENCH" in portions of this text may be shortened to "wrench."

Check (✓) the correct statement(s) below.

- ☒ 1. Any type of torque wrench is authorized for use on common aircraft hardware.
- ☐ 2. The flexible beam type torque wrench should not be used to torque a nut on an aircraft.
- ☐ 3. An aircraft technical manual will never list a type of torque wrench other than the authorized "breakaway" type.
- ☐ 4. An equipment maintenance manual may require a dial type torque wrench to be used.

Answers to Frame 73: ☐ 1. ☒ 2. ☒ 3. ☐ 4.

The breakaway torque wrench may be adjusted. The torque value you want for the unit you are to work on can be set (within limits of the torque wrench) by turning the handle (grip) to settings on the micrometer type scale. The micrometer type scale is made up of the shaft scale, on the bar part of the wrench, and the vernier scale on the handle. In the sketch below, note the shaft scale is graduated in 50 inch-pounds. The vernier scale is graduated from 0 to 50 inch-pounds which will let us change the torque setting to what is called for in the technical order.



Note: For a foot-pound torque wrench the graduation would be in foot-pounds.

Check (✓) the correct statement(s) below.

- ☐ 1. Breakaway torque wrenches are not adjustable.
- ☐ 2. The micrometer (the shaft scale and the vernier scale) is used to indicate the amount of torque set on the wrench.
- ☐ 3. The shaft scale is graduated in 50 inch-pounds.
- ☐ 4. One complete turn of the handle will give an increase or decrease of 50 inch-pounds.

Answers to Frame 74: ☐ 1. ☐ 2. ☒ 3. ☒ 4.

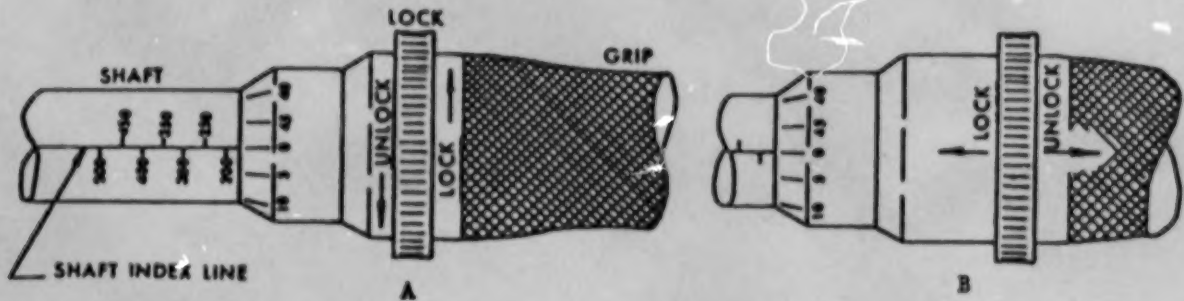
The unit you must install has a higher torque value on the nuts than you have set on the wrench. To reach this new torque value the handle (grip) must be turned to the right which will add tension to the spring in the handle. This will also make the handle shorter in length and change the reading on the micrometer type scale. If you need a lower torque, then turn the handle to the left until you pass your desired setting. You should always approach the setting you want on the wrench from the lower end of the scale.

Check the correct statement(s) below.

- ☐ 1. To change the torque value on the wrench, the handle (grip) must be turned.
- ☒ 2. A torque setting is approached from the higher end of the scale.
- ☐ 3. To increase the torque setting, the handle is turned counterclockwise.
- ☐ 4. Turning the handle reduces or increases tension on the spring inside the handle.

Answers to Frame 75: ☐ 1. ☒ 2. ☒ 3. ☒ 4.

The breakaway torque wrench has a lock to make sure that the torque value you set does not change when you use the wrench. On some of the wrenches the lock is turned (figure A) to engage and lock the handle. In other wrenches the locking is done by sliding the lock along the handle to engage a pawl or slot in the shaft (figure B). In either case, the grip is kept from turning when the wrench is in use. The lock must be "UNLOCKED" before the handle (GRIP) can be turned. The lock can only be "locked" when a number on the vernier scale (0, 5, 10, etc) is in line with the "SHAFT INDEX LINE" (see sketch below).



Check (✓) the correct statements below.

- ☒ 1. The breakaway torque wrench has a locking device.
- ☒ 2. The handle (grip) cannot be turned when the lock is "unlocked."
- ☐ 3. A number on the vernier scale must be in line with the "shaft index line" before the locking device will "lock."

Answers to Frame 76: ☒ 1. ☐ 2. ☐ 3. ☒ 4.

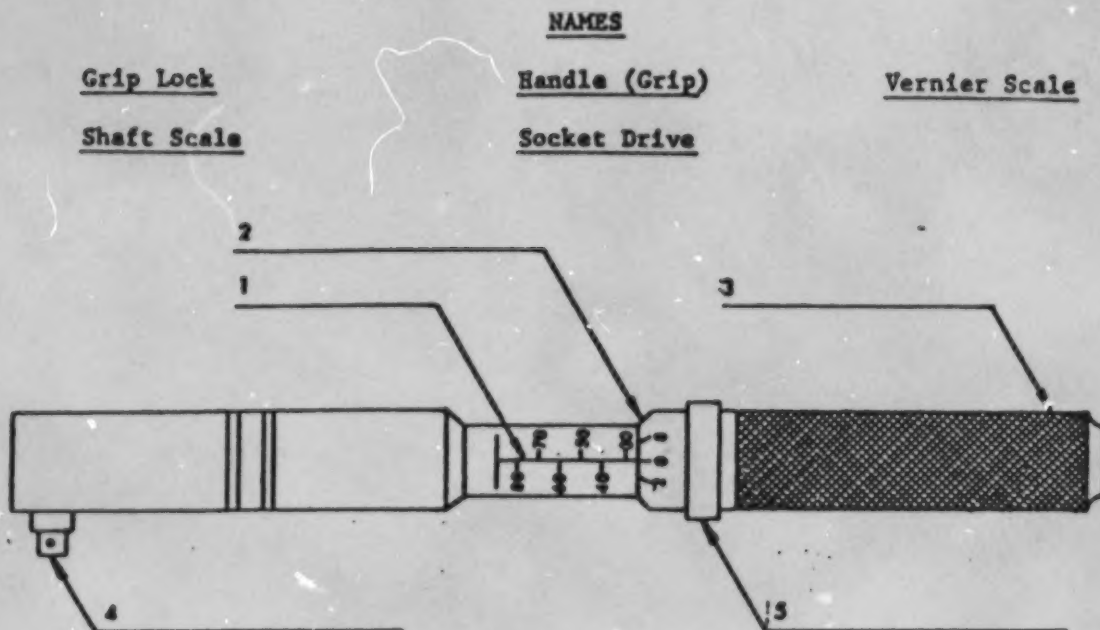
The torque wrench will automatically release or "break" when you reach a set amount of torque on a nut or bolt. When the handle releases, it will have approximately fifteen to twenty degrees of free travel and should not be pulled beyond this point.

Check (✓) the correct statement(s) below.

- ☐ 1. The handle should be pulled after it releases or "breaks."
- ☐ 2. When the handle releases or breaks the desired amount of torque has been applied.
- ☐ 3. After fifteen or twenty degrees of free travel, the handle should not be pulled beyond this point.

Answers to Frame 77: ☒ 1. ☐ 2. ☒ 3. ☐ 4.

Identify the parts of the torque wrench on the illustrated diagram below by selecting the names from the list and writing the names in the appropriate numbered spaces on the illustration.



Answers to Frame 78: 1. 2. 3.

From time to time as you use torque wrenches you may have to change inch-pounds to foot-pounds. Divide the inch-pound figure by 12 (the number of inches in a foot) to change from inch-pounds to foot-pounds. For example: 600 inch-pounds divided by 12 equals 50 foot-pounds. To change foot-pounds to inch-pounds, multiply the figure, Ex: 10 ft by 12 (number of inches in 1 ft) thus you have 10 ft by 12 in = 120 inch-pounds.

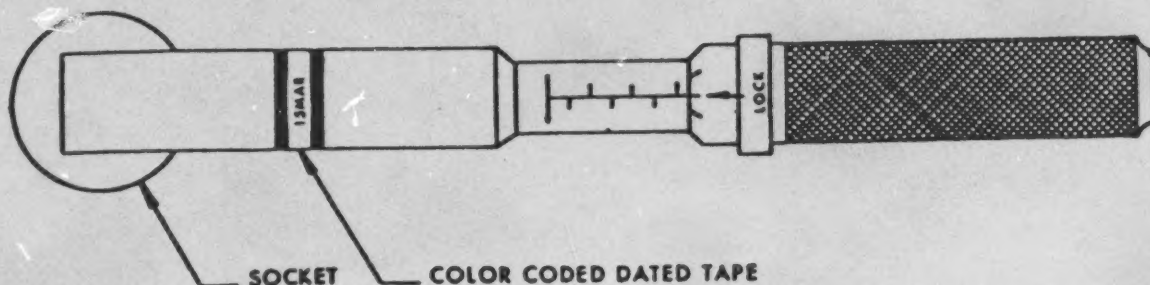
Check (✓) the correct statement(s) below.

- ___ 1. To change inch-pounds to foot-pounds divide the foot-pounds by 12.
- ___ 2. To change foot-pounds to inch-pounds multiply the foot-pounds by 12.
- ___ 3. Twelve (12) foot-pounds is equal to one (1) inch-pound.
- ___ 4. Forty-eight (48) inch-pounds is equal to four (4) foot-pounds.

Answers to Frame 79: 1. Shaft Scale 2. Vernier Scale 3. Handle
4. Socket Drive 5. Grip Lock

Torque wrenches are issued from supply to the shops or tool cribs for use when you work on planes and other critical equipment which will be verified at least once every two months (60 days). We calculate the 60 calendar days from the date of verification (see note below). For example, a wrench verified on 15 Jan 77 will be due reverification on 15 Mar 77.

Note: Verification - a check operation to determine accuracy or inaccuracy of a torque wrench, using a suitable torque wrench tester. Calibration - actual adjustment necessary to bring a torque wrench into acceptable tolerances.



Check (✓) the correct statement(s) below.

- ___ 1. Torque wrenches in the shops or tool cribs shall be verified at least once every two months (60 days).
- ___ 2. A color coded dated tape is fastened to the torque wrench during verification.
- ___ 3. A torque wrench will always be calibrated before it is verified.

Answers to Frame 80: ___ 1. ___ 2. ✓ ___ 3. ___ 4. ✓

1951

Frame 82

The following colors of tapes will be used to indicate the month the torque wrench is due verification:

<u>Colors</u>	<u>Months</u>
Blue	January-May-September
Red	February-June-October
Black	March-July-November
Yellow	April-August-December

Note: If a torque tool is dropped or otherwise abused, it will be verified and if necessary, calibrated prior to further use.

Check (✓) the correct statement(s) below.

- ☐ 1. The coded tapes will indicate the day, month and year the torque wrench was verified.
- ☐ 2. By looking at the date and color coded tape, one can determine when the torque wrench is due verification.
- ☐ 3. Each color coded tape represents three different months.

Answers to Frame 81: ☐ 1. ☒ 2. ☐ 3.

Torque wrenches are precision measuring instruments. These must be handled with care and not treated like some people who just throw their hand tools in a box. After use, you should turn the grip to the full counterclockwise position to take the tension off the spring in the handle (frame 75). If the spring is under tension all of the time, it may change the strength of the spring. The accuracy of the spring tension determines the accuracy of the wrench. You should set the wrench at its lowest setting and then store it in its own storage container.

Check (✓) the correct statement(s) below.

- ☐ 1. Torque wrenches are precision measuring instruments.
- ☐ 2. Torque wrenches are stored at their highest setting.
- ☐ 3. Torque wrenches are stored in tool boxes.
- ☐ 4. Torque wrenches are stored at their lowest setting in storage containers.

Answers to Frame 82: ☐ 1. ☒ 2. ☒ 3.

The following are a few precautions to observe concerning torque wrenches:

1. An extension shall not be used on the grip end of the handle.
2. Torque wrenches shall not be used to break loose previously tightened bolts.
3. A torque wrench shall not be used to apply a greater amount of torque than the rated capacity of the wrench.
4. Do not attempt to change setting when the handle is in the locked position.
5. Do not place an extension on the square drive that increases the length of the torque wrench without mathematically calculating the torque value to set on the handle.

NO RESPONSE REQUIRED

Answers to Frame 83: ✓ 1. 2. 3. ✓ 4.

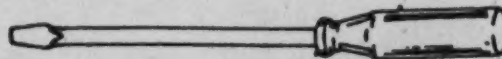
Now that you have completed the programmed text on handtools, let's review some of the information covered prior to taking the test. Answer the following questions concerning the identification and use of handtools by circling the correct response.



1. The above handtool is called a
 - a. mallet.
 - b. sledge hammer.
 - c. plastic hammer.
 - d. ball peen hammer.
2. What type of hammer is frequently used to expand the end of a rivet in a hole?
 - a. Mallet.
 - b. Sledge hammer.
 - c. Ball peen hammer.
 - d. Plastic hammer.
3. Most accidents with hammers are caused by
 - a. loose hammer heads.
 - b. sweaty hands.
 - c. greasy handles.
 - d. all of the above.

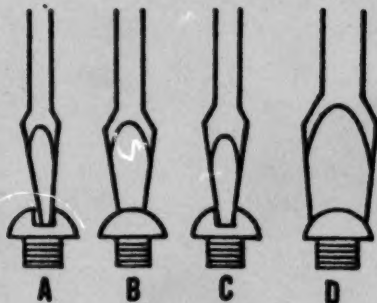


4. What type of screwdriver is used for the above screw head?
 - a. Clutchhead screwdriver.
 - b. Crosspoint screwdriver.
 - c. Common screwdriver.
 - d. Offset flat tip screwdriver.



5. What type of screwdriver is pictured above?
 - a. Offset screwdriver.
 - b. Phillips screwdriver.
 - c. Prince and Reed screwdriver.
 - d. Flat tip screwdriver.

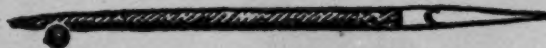
6. The size of a screwdriver is determined by
- a. the size of the blade.
 - b. the size of the handle.
 - c. the length of the screwdriver.
 - d. the combined length of the blade and the shank.



7. Which of the above illustrations shows the correct size of screwdriver to be used?
- a. A and B.
 - b. A and D.
 - c. C and D.
 - d. B and C.

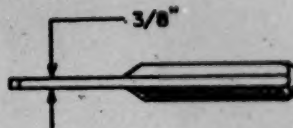


8. What tool is pictured above?
- a. Flat tip screwdriver.
 - b. Cross tip screwdriver.
 - c. Cross tip offset screwdriver.
 - d. Offset flat tip screwdriver.
9. The part of the file used when filing is called the
- a. file heel.
 - b. file face.
 - c. file tang.
 - d. file point.

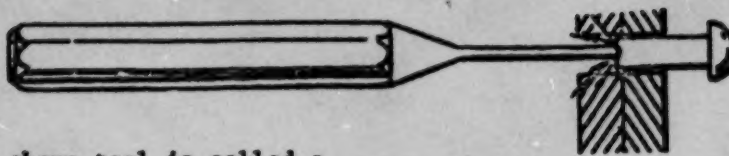


10. The above pictured file is called a
- a. half-round file.
 - b. rattail file.
 - c. taper file.
 - d. flat file.

11. Rows of teeth on a file that criss-cross each other are called a
- a. bastard grade file.
 - b. smooth grade file.
 - c. single-cut file.
 - d. double-cut file.
12. A file is properly used when
- a. only slight pressure is applied on the forward stroke.
 - b. even pressure is applied on both, the forward and backward strokes.
 - c. a smooth, firm, forward stroke is used.
 - d. a lot of pressure is applied on the forward stroke, slight pressure is applied on the return stroke.
13. The tooth-points on a hacksaw blade must
- a. be coarse enough to straddle the work.
 - b. be very small in order to clean the chips away.
 - c. face backward, towards the handle.
 - d. face forward, towards the tip of the saw.



14. The above chisel is called a
- a. cape chisel.
 - b. cold chisel.
 - c. diamond point chisel.
 - d. drift chisel.
15. To cut a "v" groove in metal, you use a
- a. diamond point chisel.
 - b. chassis chisel.
 - c. flat chisel.
 - d. hacksaw.



16. The above tool is called a
- a. drift punch.
 - b. pin punch.
 - c. center punch.
 - d. chassis punch.



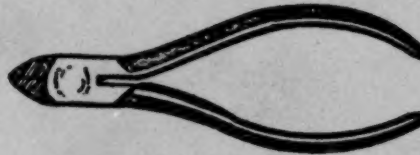
17. The above tool is called a
- a. drift punch.
 - b. pin punch.
 - c. center punch.
 - d. chassis punch.
18. To mark the locations of holes to be drilled, you use a
- a. pin punch.
 - b. drift punch.
 - c. center punch.
 - d. chassis punch.
19. Chisels and punches that have become mushroomed should be
- a. used.
 - b. thrown away.
 - c. turned in for a new one.
 - d. dressed on a grinding wheel.



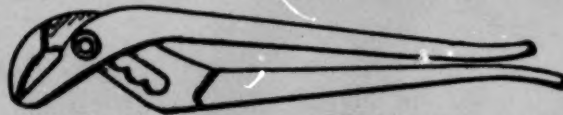
20. The above pliers are referred to as
- a. combination pliers.
 - b. wrench pliers.
 - c. water pump pliers.
 - d. conduit pliers.



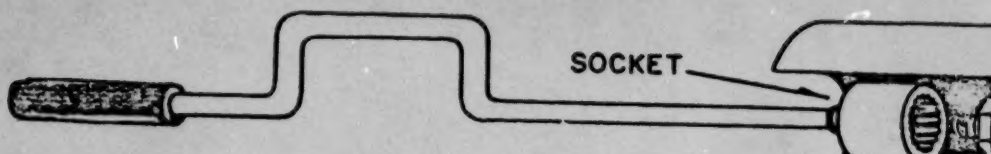
21. The above pliers are referred to as
- a. duckbill pliers.
 - b. needle-nose pliers.
 - c. combination pliers.
 - d. conduit pliers.



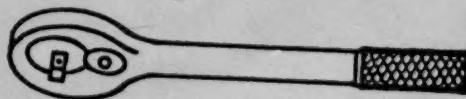
22. The above pliers are often referred to as
- a. vise grips.
 - b. wrench pliers.
 - c. dykes.
 - d. combination pliers.



23. The above pliers are often referred to as
- a. conduit pliers.
 - b. cannon plug pliers.
 - c. water pump pliers.
 - d. wrench pliers.
24. Combination pliers are commonly used to
- a. turn a nut.
 - b. cut a wire.
 - c. tighten a bolt.
 - d. bend a piece of metal.
25. To form loops in electrical wire, you would use
- a. duckbill pliers.
 - b. dykes.
 - c. wrench pliers.
 - d. needle-nose pliers.
26. To loosen a cannon plug, you would best use
- a. water pump pliers.
 - b. conduit pliers.
 - c. wrench pliers.
 - d. combination pliers.



27. The above tool is called a
- a. hinge handle.
 - b. ratchet handle.
 - c. "T" handle.
 - d. speed handle.



28. The above tool is called a
- a. hinge handle.
 - b. ratchet handle.
 - c. "T" handle.
 - d. speed handle.



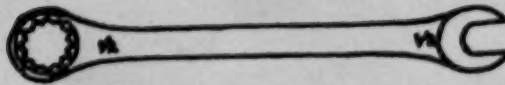
29. The above tool is called a(n)
- a. extension.
 - b. swivel socket.
 - c. universal joint.
 - d. shallow socket.



30. The above socket will fit a
- a. 3/4" drive.
 - b. 3/4" bolthead.
 - c. any size bolthead.
 - d. 3/4" drive and 3/4" bolthead.



31. The above tool is called a(n)
- | | |
|---------------------|-----------------------|
| a. universal joint. | c. socket. |
| b. adapter. | d. spark plug socket. |



32. The above tool is called a(n)
- | | |
|---------------------|------------------------|
| a. open-end wrench. | c. combination wrench. |
| b. box-end wrench. | d. adjustable wrench. |



33. The above tool is sometimes called a(n)
- | | |
|---------------------|--------------------|
| a. external wrench. | c. box-end wrench. |
| b. socket wrench. | d. Allen wrench. |
34. The best tools for removing nuts and bolts wherever possible are
- | | |
|-----------------------------|-----------------------|
| a. adjustable jaw wrenches. | c. socket wrenches. |
| b. combination pliers. | d. open-end wrenches. |

1961

Frame 85 (Continued)

35. Which socket handle can be operated without having to raise the socket off the nut for another "bite"?
- a. Hinge handle.
 - b. Ratchet handle.
 - c. Speed handle.
 - d. "T" handle.
36. To get to a nut that is located in a hard-to-get-at place, you would use a(n)
- a. adapter.
 - b. universal joint.
 - c. "T" handle.
 - d. speed handle.
37. To reduce the total number of tools required to be carried to a job, you would be best to carry a(n)
- a. universal joint.
 - b. speed handle.
 - c. adapter.
 - d. extension.
38. Which one of the following tools is best suited to remove a nut?
- a. Box-end wrench.
 - b. Open-end wrench.
 - c. Adjustable jaw wrench.
 - d. Pliers.
39. Which one of the following wrenches will yield the largest amount of torque?
- a. Short-handled open-end wrench.
 - b. Long-handled box-end wrench.
 - c. Adjustable jaw wrench.
 - d. Short-handled box-end wrench.
40. What is the correct way to use an adjustable jaw wrench?
- a. Push it toward the adjustable jaw.
 - b. Push it toward the stationary jaw.
 - c. Pull it toward the adjustable jaw.
 - d. Pull it toward the stationary jaw.

41. To measure the clearance on a spark plug gap, you would best use a
 - a. rule.
 - b. thickness gauge.
 - c. tape measure.
 - d. depth gage.
42. To connect preinsulated terminals to conductors, you would best use
 - a. wire strippers.
 - b. a knife.
 - c. a crimping tool.
 - d. Stakon pliers.
43. The drill bit on an electric drill is inserted in the
 - a. mouth.
 - b. chuck.
 - c. nose.
 - d. lock.
44. The automatic-release torque wrench is referred to as the
 - a. flexible beam type torque wrench.
 - b. dial type torque wrench.
 - c. screwdriver type torque wrench.
 - d. breakaway type torque wrench.
45. 600 inch-pounds is equal to
 - a. 50 foot-pounds.
 - b. 30 foot-pounds.
 - c. 10 foot-pounds.
 - d. 5 foot-pounds.
46. Color coded tapes on torque wrenches indicate
 - a. the torque value of the wrench.
 - b. the last calibration date.
 - c. the due date of verification.
 - d. the due date of calibration.

Answers to Frame 72

Question No Answer Review Frame

1.	- - - - - c	- - - - - 64
2.	- - - - - a	- - - - - 65
3.	- - - - - c	- - - - - 66
4.	- - - - - b	- - - - - 68
5.	- - - - - b	- - - - - 69
6.	- - - - - a	- - - - - 70

Answers to Frame 85

Question No Answer Review Frame

1.	- - - - - d	- - - - - 2
2.	- - - - - c	- - - - - 4
3.	- - - - - d	- - - - - 7
4.	- - - - - b	- - - - - 10
5.	- - - - - d	- - - - - 9
6.	- - - - - d	- - - - - 9
7.	- - - - - c	- - - - - 13
8.	- - - - - d	- - - - - 12
9.	- - - - - b	- - - - - 15
10.	- - - - - b	- - - - - 16
11.	- - - - - d	- - - - - 17
12.	- - - - - c	- - - - - 19
13.	- - - - - d	- - - - - 23
14.	- - - - - a	- - - - - 25
15.	- - - - - a	- - - - - 26
16.	- - - - - b	- - - - - 28
17.	- - - - - a	- - - - - 28
18.	- - - - - c	- - - - - 29
19.	- - - - - d	- - - - - 27
20.	- - - - - a	- - - - - 32
21.	- - - - - b	- - - - - 33
22.	- - - - - c	- - - - - 35
23.	- - - - - c	- - - - - 36
24.	- - - - - d	- - - - - 32
25.	- - - - - d	- - - - - 33

Question No Answer Review Frame

26.	- - - - - b	- - - - - 37
27.	- - - - - d	- - - - - 43
28.	- - - - - b	- - - - - 45
29.	- - - - - c	- - - - - 48
30.	- - - - - b	- - - - - 50
31.	- - - - - b	- - - - - 51
32.	- - - - - c	- - - - - 57
33.	- - - - - d	- - - - - 60
34.	- - - - - c	- - - - - 41
35.	- - - - - b	- - - - - 45
36.	- - - - - b	- - - - - 48
37.	- - - - - c	- - - - - 51
38.	- - - - - a	- - - - - 54
39.	- - - - - b	- - - - - 55
40.	- - - - - c	- - - - - 59
41.	- - - - - b	- - - - - 64
42.	- - - - - c	- - - - - 67
43.	- - - - - b	- - - - - 69
44.	- - - - - d	- - - - - 73
45.	- - - - - a	- - - - - 80
46.	- - - - - c	- - - - - 81

1964

RESPONSE SHEET

Section I

Frame 1

No Response Required

Frame 2

____ 1.

____ 2.

Frame 3

____ 1.

____ 2.

____ 3.

Frame 4

____ 1.

____ 2.

____ 3.

Frame 5

1. 1. ____

2. ____

3. ____

Frame 6

1. a. ____

2. ____ a.

____ b.

____ c.

Frame 7

____ 1.

____ 2.

____ 3.

Frame 8

____ 1.

____ 2.

____ 3.

____ 4.

Frame 9

1. ____ 1.

____ 2.

____ 3.

____ 4.

Frame 10

____ 1.

____ 2.

____ 3.

____ 4.

Frame 11

1. ____ 1.

____ 2.

____ 3.

Frame 12

1. ____ 1.

____ 2.

____ 3.

Frame 13

____ 1.

____ 2.

Frame 13 Cont'd

____ 3.

____ 4.

Frame 14

1. a, b, c, d.

2. a, b, c, d.

3. a, b, c, d.

4. a, b, c, d.

5. a, b, c, d.

6. a, b, c, d.

7. a, b, c, d.

8. a, b, c, d.

9. a, b, c, d.

10. a, b, c, d.

11. a, b, c, d.

12. a, b, c, d.

Section II

Frame 15

____ 1.

____ 2.

____ 3.

____ 4.

____ 5.

1965

RESPONSE SHEET

Section II Cont'd

Frame 16

1. ____ 1.
 ____ 2.
 ____ 3.
 ____ 4.
 2. ____ 1.
 ____ 2.
 ____ 3.
 ____ 4.

Frame 17

____ 1.
 ____ 2.
 ____ 3.
 ____ 4.

Frame 18

____ 1.
 ____ 2.
 ____ 3.

Frame 19

1. ____ 1.
 ____ 2.
 ____ 3.
 ____ 4.
 2. ____ 1.
 ____ 2.

Frame 20

1. ____ 1.
 ____ 2.

Frame 21

1. ____ 1.
 ____ 2.
 ____ 3.

Frame 22

1. ____ 1.
 ____ 2.
 ____ 3.

Frame 23

____ 1.
 ____ 2.
 ____ 3.

Frame 24

____ 1.
 ____ 2.
 ____ 3.

Frame 25

1. ____ 1.
 ____ 2.
 ____ 3.

Frame 26

____ 1.
 ____ 2.
 ____ 3.

Frame 27

1. ____ 1.
 2. ____ 1.
 ____ 2.
 ____ 3.

Frame 28

1. ____ 1.
 ____ 2.
 ____ 3.

Frame 29

1. ____ 1.
 ____ 2.
 ____ 3.
 2. ____ 1.
 ____ 2.
 ____ 3.
 ____ 4.
 ____ 5.
 ____ 6.

1966

Section II Cont'd

Frame 30

1. a, b, c, d.
2. a, b, c, d.
3. a, b, c, d.
4. a, b, c, d.
5. a, b, c, d.
6. a, b, c, d.
7. a, b, c, d.
8. a, b, c, d.
9. a, b, c, d.
10. a, b, c, d.
11. a, b, c, d.
12. a, b, c, d.
13. a, b, c, d.
14. a, b, c, d.

Section III

Frame 31

No Response Required

Frame 32

- _____ 1.
- _____ 2.
- _____ 3.

Frame 33

- _____ 1.
- _____ 2.

Frame 33 Cont'd

- _____ 3.
- _____ 4.

Frame 34

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.

Frame 35

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.

Frame 36

- _____ 1.
- _____ 2.
- _____ 3.

Frame 37

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.

Frame 38

1. _____ 1.
- _____ 2.
- _____ 3.

Frame 39

- _____ 1.
- _____ 2.
- _____ 3.

Frame 40

1. a, b, c, d.
2. a, b, c, d.
3. a, b, c, d.
4. a, b, c, d.
5. a, b, c, d.
6. a, b, c, d.
7. a, b, c, d.
8. a, b, c, d.
9. a, b, c, d.
10. a, b, c, d.

Section IV

Frame 41

- _____ 1.
- _____ 2.
- _____ 3.

Frame 42

- _____ 1.
- _____ 2.

Frame 43

- _____ 1.
- _____ 2.

1967

RESPONSE SHEET

Section IV Cont'd

Frame 44

- ____ 1.
- ____ 2.
- ____ 3.

Frame 45

- ____ 1.
- ____ 2.
- ____ 3.

Frame 46

- ____ 1.
- ____ 2.
- ____ 3.

Frame 47

- ____ 1.
- ____ 2.

Frame 48

- ____ 1.
- ____ 2.
- ____ 3.

Frame 49

- 1. ____ 1.
- ____ 2.
- ____ 3.
- ____ 4.

Frame 49 Cont'd

- ____ 5.
- ____ 6.
- 2. ____ 1.
- ____ 2.
- ____ 3.
- ____ 4.
- ____ 5.
- ____ 6.

Frame 50

- ____ 1.
- ____ 2.
- ____ 3.
- ____ 4.
- ____ 5.
- ____ 6.

Frame 51

- ____ 1.
- ____ 2.
- ____ 3.
- ____ 4.

Frame 52

- ____ 1.
- ____ 2.

Frame 53

- 1. ____ 1.
- ____ 2.
- ____ 3.
- ____ 4.
- ____ 5.
- ____ 6.
- ____ 7.
- ____ 8.
- ____ 9.
- ____ 10.
- ____ 11.
- ____ 12.
- 2. ____ 1.
- ____ 2.
- ____ 3.
- ____ 4.
- ____ 5.

Frame 54

- ____ 1.
- ____ 2.
- ____ 3.

1968

Section IV Cont'd

Frame 55

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.

Frame 56

- _____ 1.
- _____ 2.
- _____ 3.

Frame 57

- _____ 1.
- _____ 2.

Frame 58

- _____ 1.
- _____ 2.
- _____ 3.

Frame 59

- _____ 1.
- _____ 2.
- _____ 3.

Frame 60

- _____ 1.
- _____ 2.
- _____ 3.

Frame 61

- _____ 1.
- _____ 2.
- _____ 3.

Frame 62

- 1. _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- 2. _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.

Frame 63

- 1. a, b, c, d.
- 2. a, b, c, d.
- 3. a, b, c, d.
- 4. a, b, c, d.
- 5. a, b, c, d.
- 6. a, b, c, d.
- 7. a, b, c, d.
- 8. a, b, c, d.
- 9. a, b, c, d.
- 10. a, b, c, d.

Frame 63 Cont'd

- 11. a, b, c, d.
- 12. a, b, c, d.
- 13. a, b, c, d.
- 14. a, b, c, d.
- 15. a, b, c, d.
- 16. a, b, c, d.
- 17. a, b, c, d.
- 18. a, b, c, d.

Section V

Frame 64

- _____ 1.
- _____ 2.
- _____ 3.

Frame 65

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.

Frame 66

- _____ 1.
- _____ 2.
- _____ 3.

Frame 67

- _____ 1.
- _____ 2.
- _____ 3.

1969
Section V Cont'd

Frame 68

1. ____ 1.
____ 2.

Frame 69

- a.
b.
c.
d.

Frame 70

- a.
b.
c.
d.

Frame 71

- a.
b.
c.
d.

Frame 72

1. a, b, c, d.
2. a, b, c, d.
3. a, b, c, d.
4. a, b, c, d.
5. a, b, c, d.
6. a, b, c, d.

Frame 73

1. ____ 2. ____ 3. ____ 4. ____

Frame 74

1. ____ 2. ____ 3. ____ 4. ____

Frame 75

1. ____ 2. ____ 3. ____ 4. ____

Frame 76

1. ____ 2. ____ 3. ____ 4. ____

Frame 77

1. ____ 2. ____ 3. ____

Frame 78

1. ____ 2. ____ 3. ____

Frame 79

1. _____
2. _____
3. _____
4. _____
5. _____

Frame 80

1. ____ 2. ____ 3. ____ 4. ____

Frame 81

1. ____ 2. ____ 3. ____

Frame 82

1. ____ 2. ____ 3. ____

Frame 83

1. ____ 2. ____ 3. ____ 4. ____

Section VI Frame 85

1. a, b, c, d.
2. a, b, c, d.
3. a, b, c, d.
4. a, b, c, d.
5. a, b, c, d.
6. a, b, c, d.
7. a, b, c, d.

Frame 85 Con't

8. a, b, c, d. 33. a, b, c, d.
9. a, b, c, d. 34. a, b, c, d.
10. a, b, c, d. 35. a, b, c, d.
11. a, b, c, d. 36. a, b, c, d.
12. a, b, c, d. 37. a, b, c, d.
13. a, b, c, d. 38. a, b, c, d.
14. a, b, c, d. 39. a, b, c, d.
15. a, b, c, d. 40. a, b, c, d.
16. a, b, c, d. 41. a, b, c, d.
17. a, b, c, d. 42. a, b, c, d.
18. a, b, c, d. 43. a, b, c, d.
19. a, b, c, d. 44. a, b, c, d.
20. a, b, c, d. 45. a, b, c, d.
21. a, b, c, d. 46. a, b, c, d.
22. a, b, c, d.
23. a, b, c, d.
24. a, b, c, d.
25. a, b, c, d.
26. a, b, c, d.
27. a, b, c, d.
28. a, b, c, d.
29. a, b, c, d.
30. a, b, c, d.
31. a, b, c, d.
32. a, b, c, d.

TORQUE WRENCH PERFORMANCE

OBJECTIVES

After completing this worksheet you will be able to use a torque wrench to torque trainer hardware to specified values.

EQUIPMENT

Torque Handle	Basis of Issue
Hardware and Handtool Trainer	1/student
9/16" Socket Wrench	1/student
Hinge Handle	1/student

PROCEDURES

1. You will work on the handtool and hardware trainer which has a metal plate made up of nine nut and stud bolt assemblies.
2. Remove a large torque wrench, hinge handle and a 9/16" socket from tool locker #3.
3. Set the torque wrench in your hand so you can see the graduations on the grip and shaft. Compare the torque wrench to the picture below and familiarize yourself with the various parts, (shaft, grip, and lock). Look at the shaft. It is graduated in increments of 50, (i.e., 100, 150, 200, 250). These figures are inch pounds. Now look at the grip index. It is graduated from 0 to 50 inch pounds in increments of 5 inch pounds. By turning the grip and aligning one of the grip index increment markings on the centerline of the shaft increment markings we can get any torque setting we want from 100 to 750 inch pounds, to the nearest 5 inch pounds.

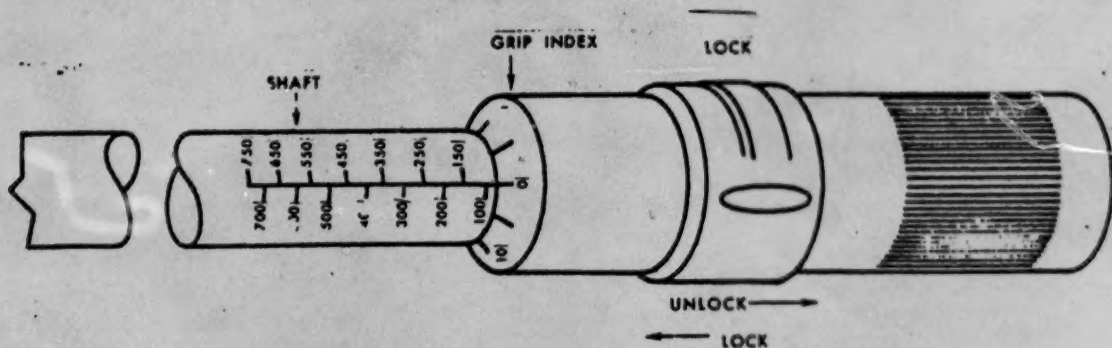


Figure 1.

Supersedes 3ABR42231-WB-303, 23 January 1973, which may be used until existing stocks are exhausted.

OPR: TASTC

DISTRIBUTION: X

TASTC - 150; TTVGC - 2

Designed for ATC Course Use. Do Not Use on the Job.

1971 4. Slide the locking ring to the rear to unlock the torque wrench handle.

5. Turn the hand grip clockwise until the "0" on the grip index is aligned with the 200 on the shaft. The wrench is now set to "breakaway" at exactly 200 inch pounds.

6. Slide the locking ring forward (see figure 1) to lock the grip at exactly 200 inch pounds; this will prevent a change in the setting as you use the wrench. Note that it is impossible to lock the grip if any of the index lines are not exactly aligned with the line on the shaft; i.e., it will lock at 200 inch pounds and at 205 inch pounds, but not at 201, 202, 203, or 204 inch pounds.

7. Attach the 9/16 inch socket wrench to the square drive on the end of the torque wrench.

8. Set yourself near the trainer so you can comfortably reach the nine stud bolt and nut assemblies.

9. Finger tighten three of the nine stud bolt assemblies until they are JUST BARELY SNUG - NOT TIGHT.

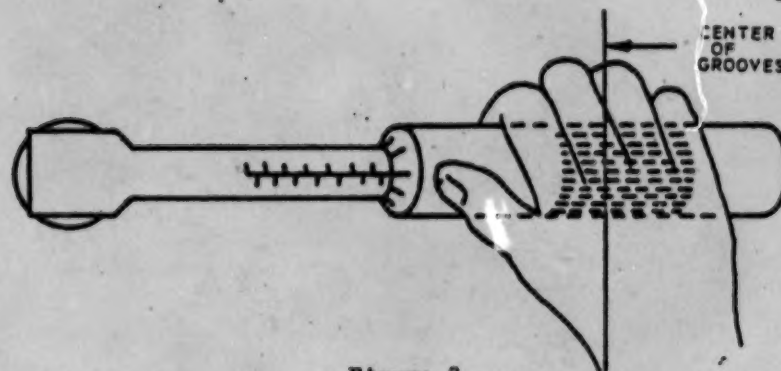


Figure 2.

10. Read this entire frame before you continue.

a. Place the socket of your torque wrench on one of the three nuts.

b. Holding the torque wrench as shown in figure 2, and using a very steady, smooth pull, pull the handle toward you. DO NOT STOP. It is important you do not stop or an inaccurate torque will result. If this should happen - loosen the nut with the hinge handle and start your tightening procedure OVER.

c. The wrench will suddenly "break-away" (it will feel to you as though the wrench has slightly slipped). DO NOT PULL BEYOND THIS POINT. It means the nut has been torqued to exactly 200 inch pounds.

11. Remove the socket and torque wrench from the nut you have just torqued.

12. Turn the grip back until the 150 inch pound index is exposed. 1972

13. Set the grip to exactly 175 inch pounds, (figure 3). After you have done this, check figure 3 to see if your torque setting is exactly the same. 150 on the shaft scale plus 25 on the grip index = 175 inch pounds.

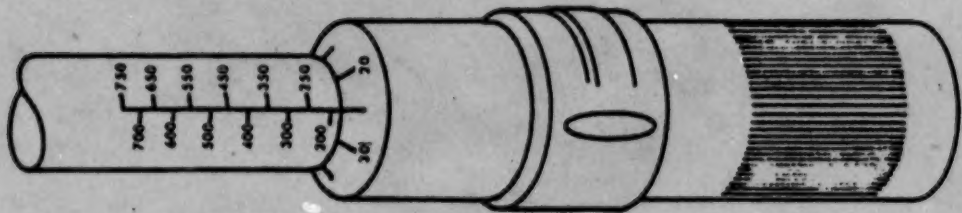


Figure 3.

14. Lock the grip.

15. Torque one of the remaining two nuts to the break-away point (175 inch pounds). You may go back to any step in this project that will clear up any doubts you might have.

16. Torque the final (third) nut to exactly 105 inch pounds (figure 4). Check the accuracy of your setting by referring to the illustration below. 100 on the shaft scale plus 5 on the grip index = 105 inch pounds.

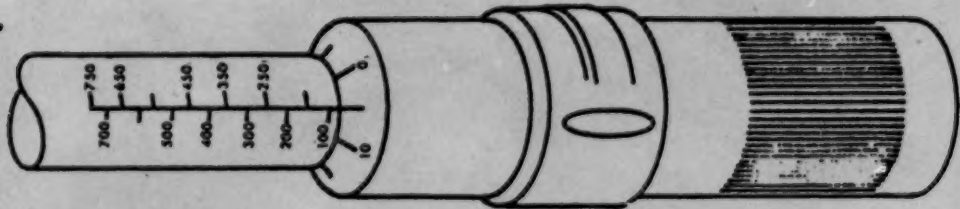


Figure 4.

17. You have correctly torqued three bolts; each at a different setting and in each case using the proper procedures.

18. Using the hinge handle, loosen all three nuts on the trainer.

19. Take the socket off the torque handle.

20. Set the torque wrench to its LOWEST SETTING. This is important since it relieves the tension on the internal mechanism of the wrench.

1973

21. Put the torque wrench back in tool locker #3. Case back in the tool cabinet. Put the 9/16" socket wrench and 9/16" hinge handle in the locker also.

22. Tell the instructor that you have completed this project.

1974

PROGRAMMED TEXT
3ABR42331 - PT-303A
3ABR32531-PT-107
3ABR42132-PT-110A

Technical Training

Aircraft Environmental Systems Repairman
Avionics Instrument System Specialist
Aircraft Pneudraulic Repairman

AIRCRAFT HARDWARE

8 April 1976



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3370th Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.

DO NOT USE ON THE JOB.

74-20000

1975

FOREWORD

This programmed text was prepared for use in the Avionics Instrument Systems Specialist, 3ABR32531; Aircraft Environmental Systems Repairman, 3ABR42231; Aircraft Pneudraulics Repairman, 3ABR42132 Courses. The materials contained herein were validated by 30 students from the Avionics Instrument Systems Specialist Course. At least 90% of the students achieved the objectives using a hardware trainer. Average time for completion of this text was one hour and 57 minutes.

OBJECTIVES

At the completion of this programmed text, you should be able to complete the following objectives:

1. Using a hardware trainer or illustration match bolts to their nomenclature. 75% accuracy is required.
2. Using a hardware trainer or illustration, match screws to their nomenclature. 75% accuracy is required.
3. Using a hardware trainer or illustration, match nuts and/or washers to their nomenclature. Four of six must be correctly matched.
4. Using a hardware trainer or illustration, match AN fittings to their nomenclature. 75% accuracy is required.
5. Without the aid of references, match aircraft tubing and hose to their purpose. 75% accuracy is required.

INSTRUCTIONS

This text is presented in small steps called "frames." After each frame you are to select the correct statements, choose either TRUE or FALSE, or match names of items to nomenclature. All answers will be made on provided answer sheets, "NOT IN THE PT." After answering the questions compare your answers with the correct ones found at the bottom of the following page. If your answer is correct, go to the next frame. If your answer was wrong, read the frame again and see how the correct response was derived. READ VERY CAREFULLY AND DO NOT HURRY. This program text was designed for three courses, Environmental Systems Repairman, Pneudraulic Repairman, and Instrument Systems Specialist. Due to the difference of the instructional material of each course ENVIRONMENTAL SYSTEMS COURSE DO NOT USE FRAMES 48, 49 AND 50. When you come to the end of the text, be sure to use the terminal frame designed for your course. Pneudraulics use terminal Frame 51, Instrument 51A and Environmental 51B. At the back of this text you will find answer sheets. Turn to the back and remove one set now. Proceed to Frame 1 at the top of the next page and begin.

Supersedes 3ABR42231-PT-303A, etc., 14 August 1974. Previous editions of this PT can be used until the present stock is depleted.

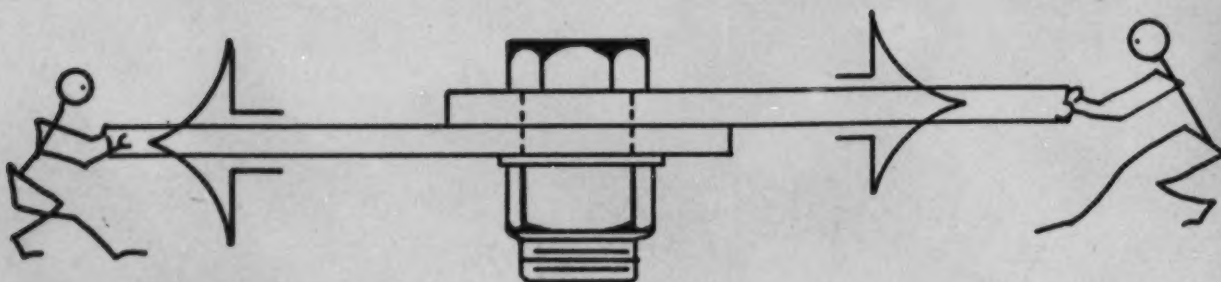
OPR: TAS

DISTRIBUTION: X

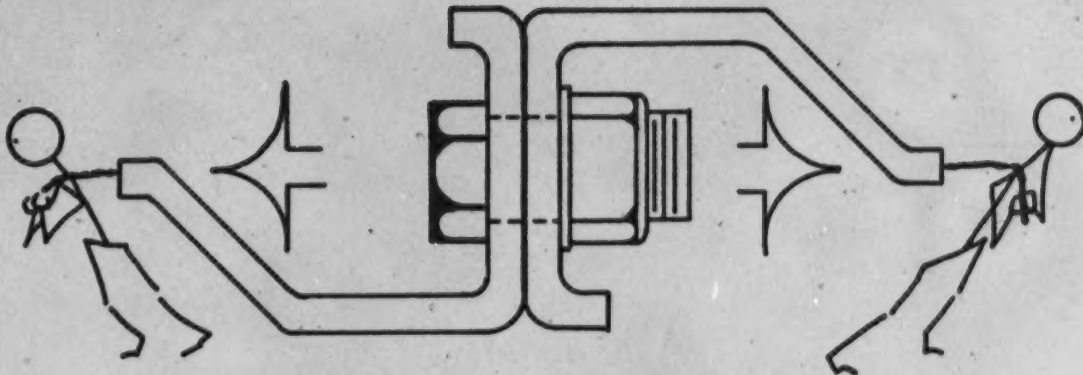
TAS - 300; TTVGC - 1

Most bolts used in aircraft structures are classed as general purpose, AN (Army-Navy), NAS (National Aircraft Standard), or MS (Military Standard) bolts. These bolts are made of aluminum alloy where lightness is needed, or of steel when strength is needed. Before going any further, study the terms and their definitions. They will help you understand why so many different types of bolts are necessary in the Air Force.

1. **STRAIN** - Strain is the deformation of a material when some force is applied to it. Just as you can strain a muscle by trying to lift a heavy weight, a bolt can be strained by being over tightened.
2. **STRESS** - Stress is a result of strain. When a bolt is being strained, it tries to resist the forces that cause the strain. Stress is measured in pounds per square inch (PSI).
3. **TENSION** - Tension is the act or action of stretching. Tension is also a type of stress which occurs when a bolt is elongated or stretched in a straight line.
4. **SHEAR** - Shear is an action or stress which causes a material to slide in a parallel plane. Shear occurs when force is applied to a bolt from opposite sides. (Think of how paper is cut with a pair of scissors.)
5. **TENSILE STRENGTH** - Tensile strength is a measure of the amount of stretch or elongation a bolt can stand and not tear apart. (Think of this as resistance to stretching or a straight line pull.)
6. **SHEAR STRENGTH** - Shear strength is a measure of the amount of side pressure a bolt can stand and not break in two. (Think of this as resistance to side pressure.)



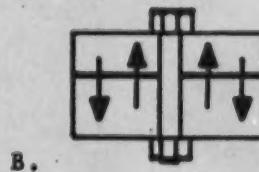
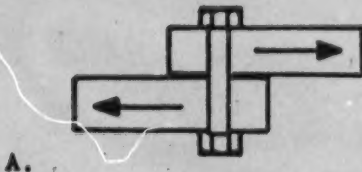
Force in this direction causes SHEAR STRESS.



Force in this direction causes TENSILE STRESS.

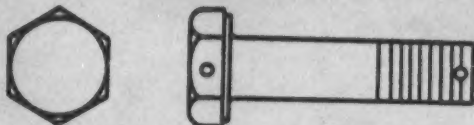
Identify the type of stress being applied to each bolt.

1. Tensile.
2. Shear.



Three general types of bolts are: standard aircraft bolts, clevis bolts, and eyebolts.

Standard aircraft bolts (machine bolts) are all-purpose structural bolts used for general applications involving tension or shear loads. These bolts may or may not have a hole drilled in the shank or head; sometimes, both the head and the shank are drilled. The drilled hole in the head of the bolt is used when the bolt must be safety wired. The hole in the bolt shank is used when the nut must be secured by a cotter pin to keep it from turning or working loose.



STANDARD AIRCRAFT MACHINE BOLT

Answer the statements as true (T) or false (F).

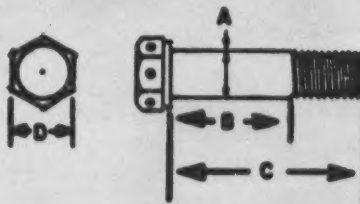
1. Standard aircraft machine bolts sometimes have drilled shanks.
2. Standard aircraft machine bolts may not be used with safety wire.

Answers to Frame 1: 1. B, 2. A

The size of a bolt is determined by the diameter of the shank. The size wrench to use on it is determined by the distance across the flat part of the head. The length of a bolt is measured from below the head to the end of the threads. The grip length of a bolt is the unthreaded part of the shank.

Match the names of the different parts of the bolt with the letters.

1. Diameter.
2. Length.
3. Grip.
4. Head (Wrench Size).



Answers to Frame 2: 1. T, 2. F

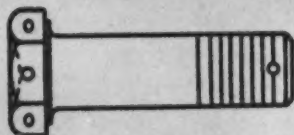
The grip length of a bolt should equal the thickness of the material it passes through. The threads should not bear on the material nor should the grip extend beyond the outer surface of the material.

Answer the statements as true (T) or false (F).

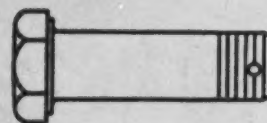
1. A bolt with a 1 inch grip length may be used to hold two pieces of 1/2 inch material together.
2. A bolt with a 1 inch grip length may be used to hold two pieces of 1/4 inch material together.

Answers to Frame 3: 1. a, 2. c, 3. b, 4. d

Close-tolerance hex head bolts are used where the bolted joint is subject to severe load reversals and vibration. The shank of this type bolt has a very accurate diameter (close-tolerance) which permits a very close fit in a close-tolerance hole. These bolts are available as tensile bolts with drilled heads or drilled shanks, and as shear bolts with or without a cotter pin hole.

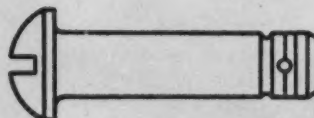


HEX HEAD, CLOSE-TOLERANCE TENSILE BOLT



CLOSE-TOLERANCE SHEAR BOLT

Clevis bolts are made of steel and are used in applications subject to shearing stress only, such as is shown in the illustration below. Note that the force exerted on the bolt is crosswise on the shank. Clevis bolts are also used as mechanical pins in control systems.

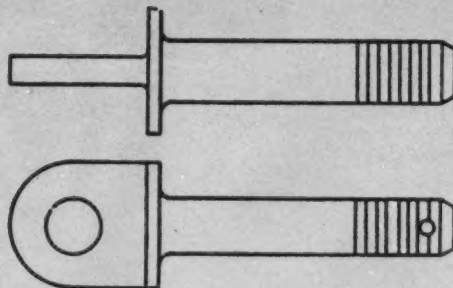


Answer the question.

1. Which bolt is used where resistance to shear is needed?
 - a. Clevis bolt
 - b. Plain head aircraft bolt
 - c. Drilled head aircraft bolt
 - d. Eyebolt

Answers to Frame 4: 1. T, 2. F

Eyebolts are used to carry external tension loads for the attachment of devices such as the fork of a turnbuckle, a clevis, or a cable shackle.

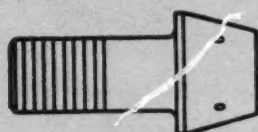


Match the illustrations to the correct name listed in the column on the right.

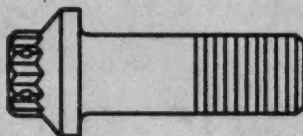
- | | | | |
|----|--|--|----------------------------|
| 1. | | | a. Standard Aircraft Bolt |
| 2. | | | b. Eyebolt |
| 3. | | | c. External Wrenching Bolt |
| | | | d. Clevis Bolt |

Answer to Frame 5: 1. a

Internal wrenching bolts are high strength steel bolts used in tension applications like bolting the wing on to the fuselage. The bolt hole must be countersunk to seat the larger corner radius of the shank at the head. If the bolt hole is not countersunk a special heat-treated washer must be used to fit the head and to provide a good bearing area. A special plain washer, also heat-treated, is used under the nut which is also a special nut for use with these bolts.



The external wrenching bolt has a 12-point head. This bolt has greater fatigue resistance and tensile strength, than conventional bolts.

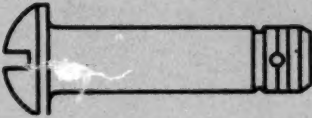
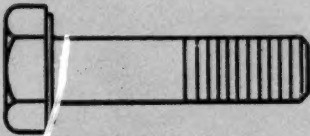
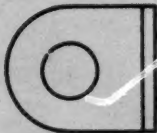
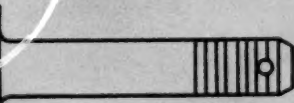
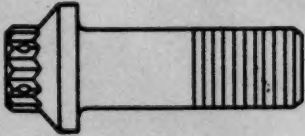


Is the statement TRUE or FALSE?

1. ☒ An internal wrenching bolt may be used with any type of nut.

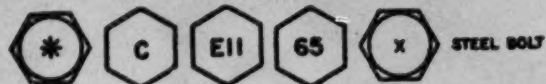
Answers to Frame 6: 1. d, 2. a, 3. b

Match the illustrations to the correct name listed in the column on the right.

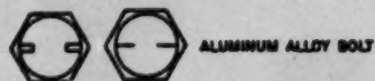
- | | | | |
|----|---|---|----------------------------|
| 1. |  |  | a. Standard Aircraft Bolt |
| 2. |  |  | b. Eyebolt |
| 3. |  |  | c. External Wrenching Bolt |
| 4. |  |  | d. Clevis Bolt |

Answer to Frame 7: 1. FALSE

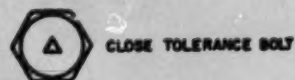
Bolt heads are marked with a code to identify their physical characteristics and materials. Steel bolts are marked with an asterisk (*), letters from A to Z, or numbers from 0 to 9, or any combination of letters, numbers, and an asterisk.



Aluminum bolts are marked with raised or recessed dashes on opposite sides of the head.



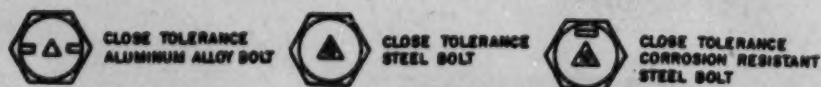
Steel and aluminum close-tolerance bolts are identified by a raised or recessed triangle on top of the head.



Corrosion resistant steel bolts are identified by a single raised or recessed dash on top of the head.



Some bolts may have a combination of materials or other characteristics, and are identified as shown.



Answers to Frame 8: 1. d, 2. a, 3. b, 4. c

Match the bolts by identifying marks with the statements on the left.

1. Close Tolerance Aluminum Bolt

a.



2. Steel Bolt

b.



3. Corrosion Resistant Steel Bolt

c.



4. Aluminum Bolt

d.



5. Close Tolerance Bolt

f.



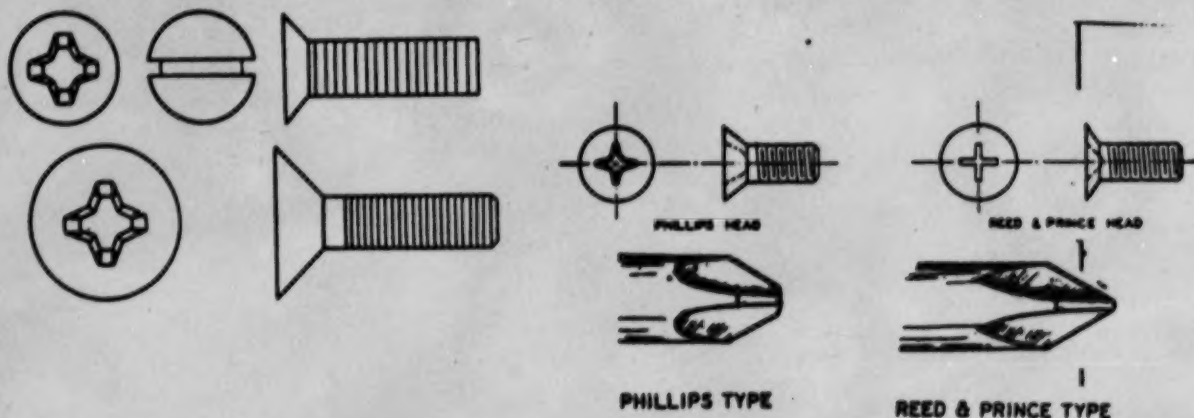
1987
Frame 10

Screws are the most common type of fasteners used on aircraft. They differ from bolts mainly by having a lower material strength and a loose thread fit. The different types of screws have various type of slots or recesses. For each type of screw a particular type of screwdriver is used. To prevent damaging the screw head and the screwdriver, always use a screwdriver that will match the slot.

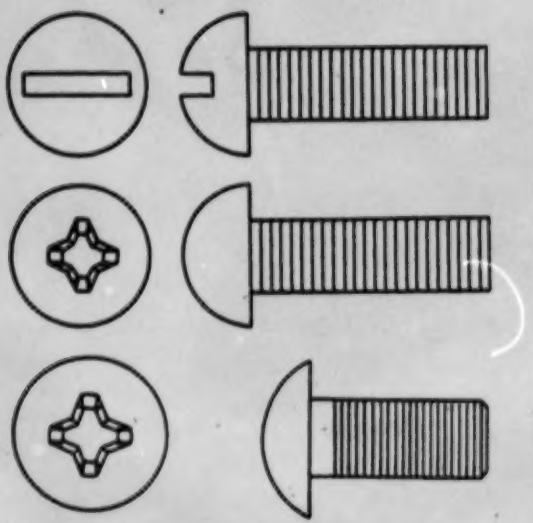
NO RESPONSE REQUIRED

Answers to Frame 9: 1. d, 2. c, 3. e, 4. b, 5. a

Flathead machine screws are used in countersunk holes where a flush surface is desired. These screws have various types of screwdriver slots. Such as; the Phillips, the Reed and Prince (crosspoints) and the common slot. To recognize the Reed and Prince, look for the square cut corners of the screw slot and the sharp point of the screwdriver. The Phillips screw slot is larger with curved corners and the screwdriver point is blunt.



General purpose roundhead machine screws, like flathead machine screws, are made from different materials. They may have coarse or fine threads and slotted or recessed heads. Brass roundhead machine screws, with a slotted head are for electrical use only.



Answer to Frame 10: None Required

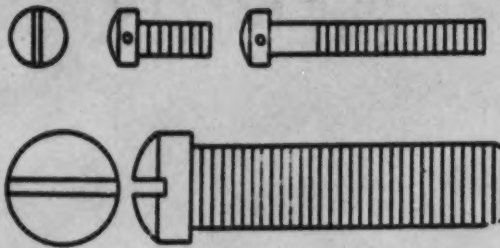
1989

Frame 11 (Cont'd)

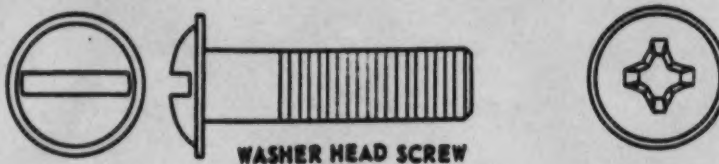
Answer the questions, by supplying the information required, or by indicating TRUE or FALSE.

1. A flathead machine screw is used in a _____ hole where a flush surface is required.
2. A brass roundhead machine screw is designed for general purpose use.

Fillister head machine screws are used as general purpose screws. The head are usually drilled for safety wire. Fillister head screws are made of steel and brass, and have coarse or fine threads.



The washer head screw, while not a machine screw, is used in much the same way that structural bolts and rivets are used. These screws have a high tensile strength and differ from structural bolts only in the type of head.



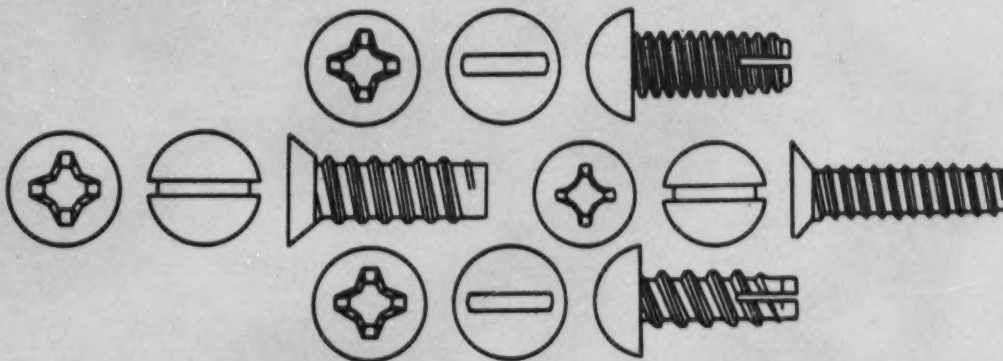
Complete the statement.

1. The type of screw which has a drilled head, for safety-wiring, is the
 - a. washer head screw.
 - b. flathead machine screw.
 - c. fillister head machine screw.
 - d. roundhead machine screw.

Answers to Frame 11: 1. countersunk, 2. FALSE

Self-tapping screws tap their own threads. The screw should be used in untapped or punched holes slightly smaller than the outside diameter of the screws.

Self-tapping sheet metal screws are used for attaching sheet metal for riveting and for permanent assembly of nonstructural assemblies. Sheet metal screws are hardened for use on steel or aluminum sheets. They may also be used on plastic.



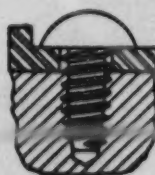
IN DRILLED
OR CLEAN
PUNCHED
HOLES



IN PIERCE
PUNCHED
HOLES



IN CUT
COUNTERSUNK
HOLES



IN CASTINGS
PLASTICS,
ETC.



IN CLEARANCE
HOLES OF
LINE CLAMPS,
FAIRLEADS, ETC

Using Sheet Metal Screws

Is the following statement TRUE or FALSE?

1. In a permanent installation, sheet metal screws must be used in tapped holes or with self-locking nuts.

Answer to Frame 12: 1. c

Drive screws are self-tapping screws used to attach nameplates to castings. The screws are also used to seal drain holes in flat structures. They differ from other self-tapping screws in that the heads are not formed to fit screwdrivers. They are not designed to be removed after installation. Drive screws are installed by driving the screw into a hole with a hammer.



ROUNDHEAD DRIVE SCREW

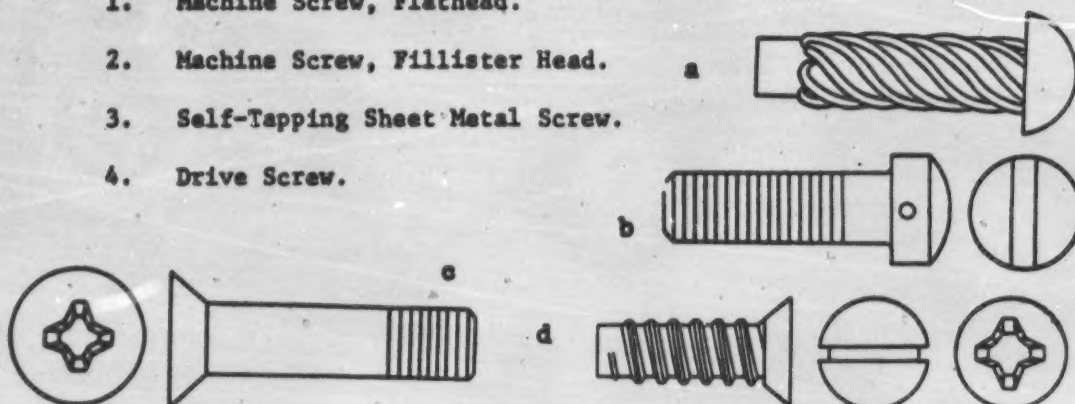
Complete the statement.

1. The correct tool for installing a drive screw is
 - a. Phillips screwdriver.
 - b. Reed and Prince screwdriver.
 - c. common screwdriver.
 - d. hammer.

Answer to Frame 13: 1. FALSE

Match the screws with the correct nomenclature.

1. Machine Screw, Flathead.
2. Machine Screw, Fillister Head.
3. Self-Tapping Sheet Metal Screw.
4. Drive Screw.

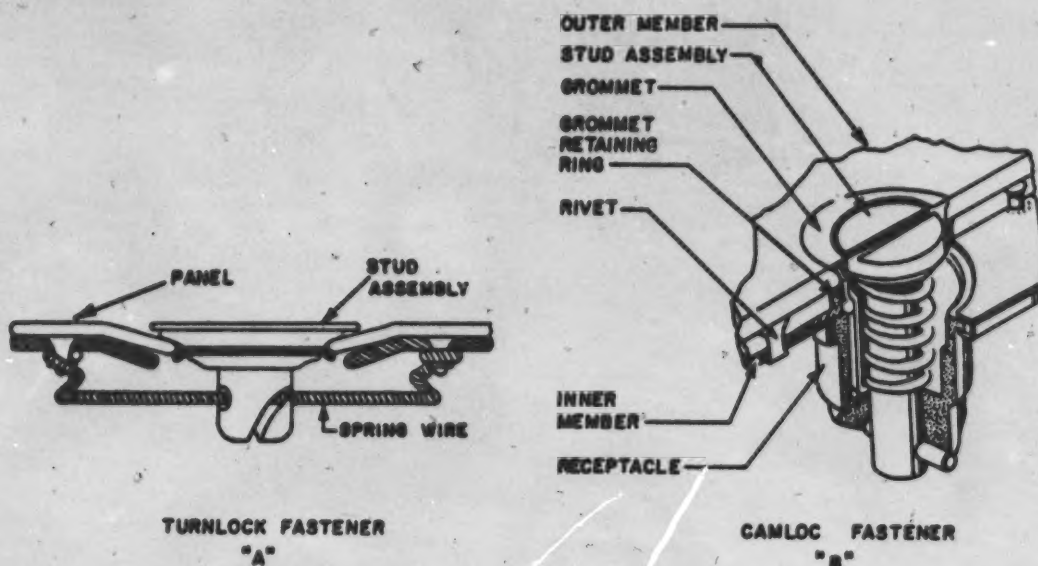


Answer to Frame 14: 1. d

Quick release fasteners are used on aircraft access panels, plates, etc. where quick or frequent access is necessary. The two types of fasteners are the turnlock (Dzus) and Camlock. The advantage of these fasteners is that one-quarter turn locks or unlocks them.

Turnlock fasteners (see illustration "A") are made to be used on cowlings (engine covering) and access doors, where there is no structural stress required.

Camlock fasteners (see illustration "B") are of high strength and are used in some areas on access panels and doors where some stress is required.



Answer the statements as true (T) or false (F).

1. Fasteners are used where frequent and quick accesses are required.
2. Turnlock fasteners can carry high structural stresses.

Answers to Frame 15: 1. c, 2. b, 3. d, 4. a

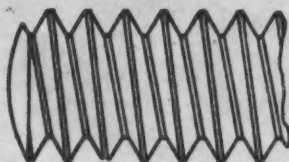
Select the correct answer.

1. What type of screw is used to attach panels to aircraft where there is a threaded hole in the aircraft?
 - a. Machine screw
 - b. Drive screw
 - c. Sheet metal screw
 - d. Crosspoint screw
2. The type of machine screw which has a drilled head for securing safety wire is the
 - a. flathead machine screw.
 - b. washer head structural screw.
 - c. roundhead machine screw.
 - d. fillister head machine screw.
3. For quick access panels, cowling and plates are secured to the aircraft with
 - a. flathead machine screws.
 - b. sheet metal screws.
 - c. fasteners.
 - d. fillister head machine screws.
4. A screw that has high tensile strength and is used in the primary structure of aircraft is the
 - a. sheet metal screw.
 - b. drive screw.
 - c. crosspoint screw.
 - d. washer head screw.

Answers to Frame 16: 1. T, 2. F

The more common forms of screw threads are known as unified national and American national taper pipe thread. Unified national screws are made with coarse, fine, and extra fine threads. See the illustration below.

Screw Thread Forms.



① UNIFIED NATIONAL SCREW THREAD



② AMERICAN NATIONAL TAPER PIPE THREAD

Answer the following TRUE or FALSE.

1. The unified national screw thread has a taper.

Answers to Frame 17: 1. a, 2. d, 3. c, 4. d

Plain nuts are not self-locking. When these nuts are used, they shall be locked with some type of locking device. The device can be a checknut or lockwasher.



Safetying by Use of Nuts.

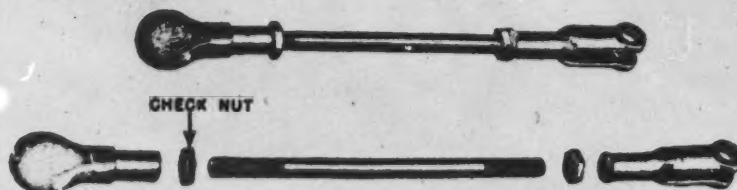


A checknut is a type of plain nut used to lock a plain nut. They are also used as locking devices for set screws and threaded rod ends. Shown are two ways checknuts are used. Study the illustrations above and below. Checknuts are thinner than plain nuts.



Is the following statement TRUE or FALSE?

1. An alternate method of locking (safetying) a nonself-locking plain nut is through the use of safety wire.



Answer to Frame 18: 1. FALSE

Castellated nuts are used on drilled shank bolts, clevis bolts, and drilled head studs. These nuts can be secured with cotter pins or safety wire. The multiple slot arrangement permits proper adjustment of tension with the correct alignment of slots and holes.



CASTELLATED NUT

The illustration below shows how to use a cotter pin to secure a castellated nut. Shear nuts are also made for use with devices, such as: clevis bolts and threaded taper pins that are subjected to stress instead of tension. A shear nut has at least three threads below the castellations. Shear nuts are thin and are available in the self-locking style.



Safetying by Use
of Cotter Pins.



SHEAR NUT

The wingnut is used where the desired tightness is obtained by the use of the fingers and where the assembly is frequently removed. When safetying of this nut is required, a hole is drilled through one of the "wings" and secured with safety wire.



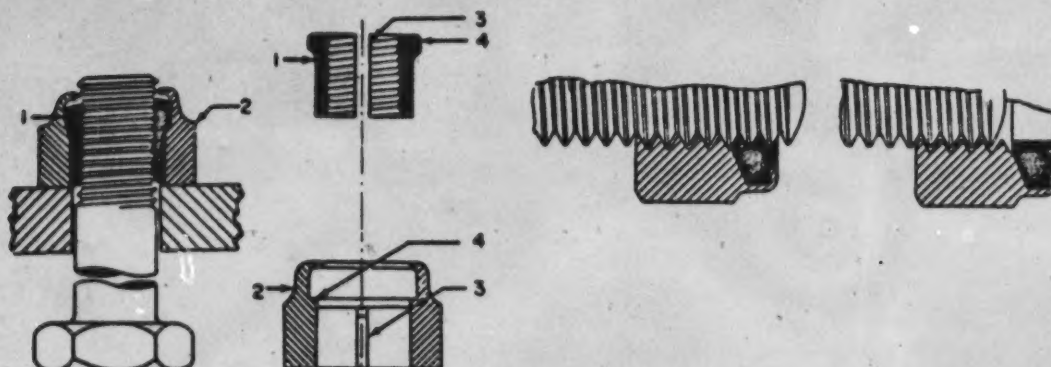
WING NUT

Answer the statements as true (T) or false (F).

1. The correct use for a castellated nut is with a drilled head bolt.
2. A shear nut is most generally used with a clevis bolt.
3. Wing nuts are used where the desired tightness is obtained by the use of the fingers.

Answer to Frame 19: 1. FALSE

Nonmetallic type self-locking nuts have a nylon insert. The insert has a smaller inside diameter than that of the bolt. The nylon puts a locking force on the bolt.



1 THREADED NUT CORE
2 NUT CASE
3 KEYWAY
4 LOCKING SHOULDER

Nonmetallic self-locking nuts shall not be subjected to temperatures in excess of 250 degrees Fahrenheit. As illustrated in the diagram, self-locking nuts are available in thick or thin styles.



THICK. THIN.
SELF LOCKING NUTS

All metal self-locking nuts are similar to nonmetallic self-locking nuts except the type of insert. The nuts are used where temperatures are extremely high (3060°F. Exhaust section of jet engine). The all-metal self-locking nut has threads out of phase or pinched in at the top to bind the bolt and maintain tightness.

New self-locking nuts must be used each time components are installed in critical areas throughout entire aerospace vehicle including all flight, engine, turbopropeller, and fuel control linkage and attachments.

Answers to Frame 20: 1. F, 2. T, 3. T

Complete the statement.

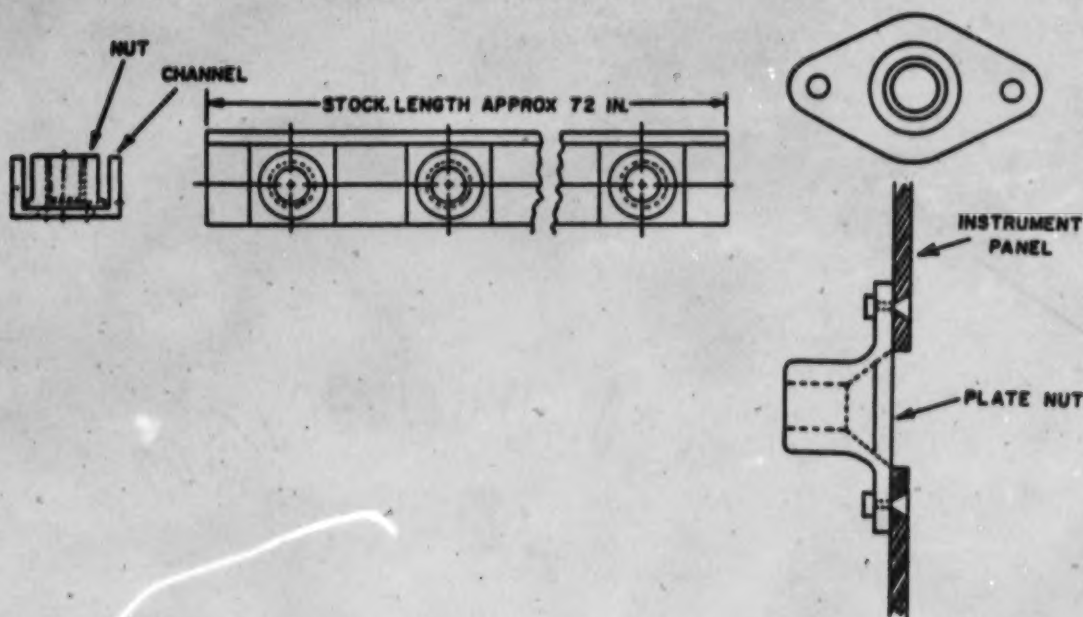
1. The type of nut, which must not be used in applications where the temperature is above 250 degrees Fahrenheit, is the
 - a. castellated nut.
 - b. all-metal self-locking nut.
 - c. nonmetallic self-locking nut.
 - d. plain nut.

Match the descriptions on the right with the names on the left.

- | | |
|---------------------------------|---|
| 1. Nonmetallic self-locking nut | a. has slots at the top to be used with drilled bolts with a cotter pin to maintain its position. |
| 2. Castellated nut | b. has threads out of phase or pinched in at the top to bind on the bolt and maintain tightness. |
| 3. All metal self-locking nut | c. requires an auxiliary lockin device, such as a check-nut or lockwasher. |
| 4. Plain nut | d. has a nylon insert at the top to bind on the bolt and maintain tightness. |

Answer to Frame 21: 1. c

Plain nuts are used for blind mounting and for easier maintenance. They can be either self-locking or plain. They are made in a wide range of sizes and shapes. One lug, two lugs, and right-angle shapes are made to fit various nut locations. Floating-type nuts give a controlled amount of nut movement to compensate for subassembly misalignment during installation.



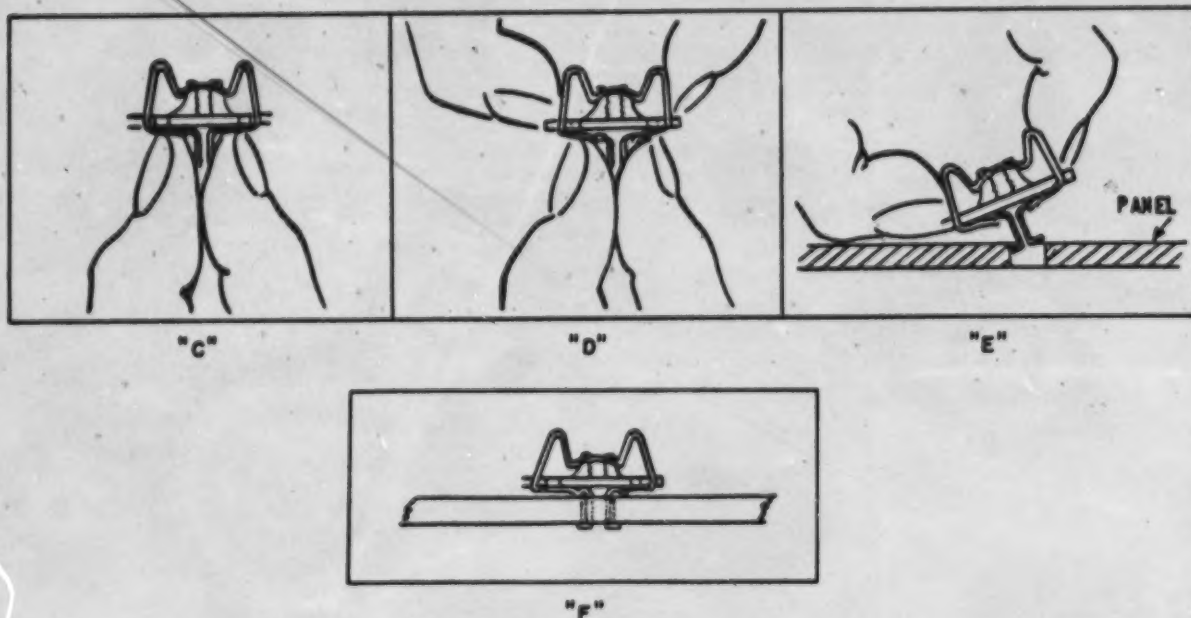
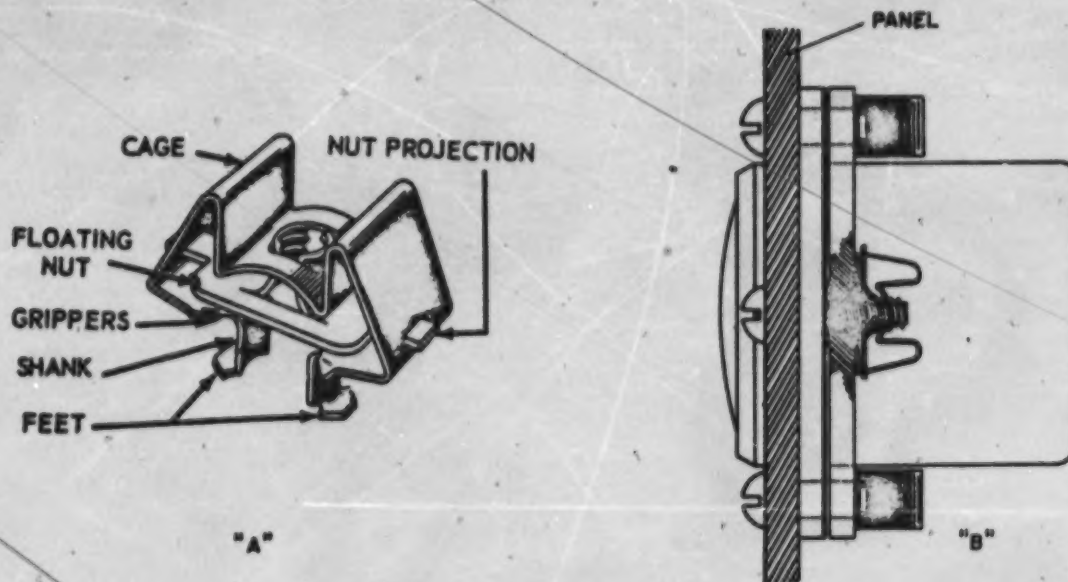
Gang channel nuts are used where anchored nuts must be equally spaced around openings. Some examples are access and inspection doors and removable leading edges. Straight or curved channel strips give a wide range of nut spacing. They are a multiple nut unit that has all advantages of float-type nuts. They are self-locking.

Answer the statements as true (T) or false (F).

1. Plate nuts are used for mountings that are easy to reach.
2. A float-type nut has some movement to compensate for misalignment of subassemblies.
3. Gang channel nuts are anchored and equally spaced.

Answers to Frame 22: 1. d, 2. a, 3. b, 4. c

Instrument mounting nuts are used for front mounting of aircraft instruments. The nuts may be put in the instrument for rear mounting (see illustration "B"). The nut is made of nonmagnetic material and is used just with a standard instrument mounting screw, size 6-32. The names of the parts of the nut are shown in illustration "A". There are several shank lengths to fit the different panels and bezel thicknesses. Illustrations "C" through "F" shows how a nut is put in the instrument panel.



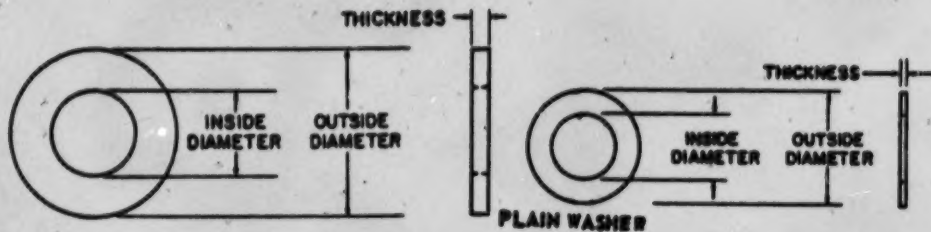
Answers to Frame 23: 1. F, 2. T, 3. T

Answer the statements as true (T) or false (F).

1. Instrument mounting nuts come in several sizes.
2. Instrument mounting nuts can be used on front mounted instruments only.
3. Instrument mounting nuts are available in several different shank lengths.
4. Instrument mounting nuts that are attached to the instrument would require the instrument to be rear mounted.

The types of washers used in aircraft structures are plain washers, lockwashers, and special washers.

Plain washers are used under nuts to provide a smooth bearing surface. They can be used as shims to adjust the position of castellated nuts with respect to drilled cotter pin holes in bolts. They are also used under lockwashers to prevent damage to surfaces of soft material.

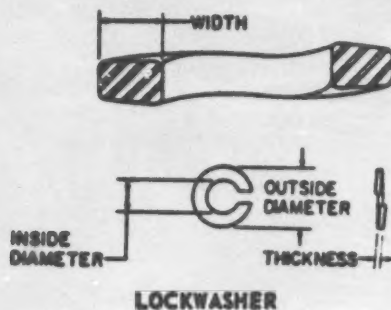


Complete the statement.

1. Plain washers are used under nuts to
 - a. prevent a galvanic action from dissimilar metals.
 - b. provide a smooth bearing surface.
 - c. prevent loosening of threaded fasteners.
 - d. act as shims between the threads of bolts and nuts.

Answers to Frame 24: 1. F, 2. F, 3. T, 4. T

Lockwashers are used with plain nuts when self-locking or castellated type nuts are not used. The spring action of the washer keeps the nut from working loose. Lockwashers are not to be used where failure of the washer might cause damage or danger to aircraft or personnel. The following diagram shows a lockwasher.

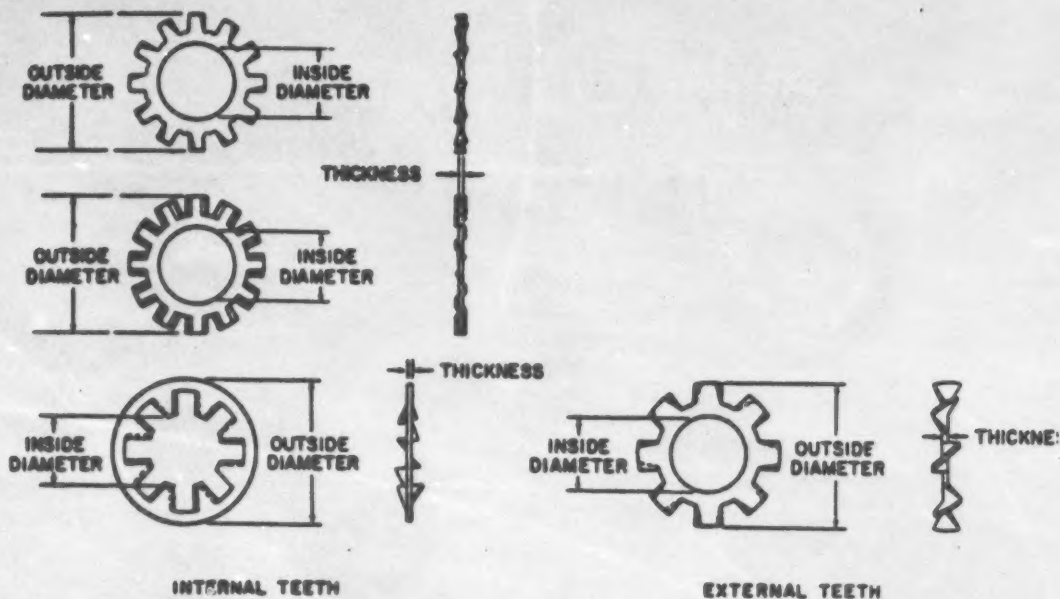


Complete the statement.

1. Lockwashers are used with plain nuts
 - a. when self-locking or castellated type nuts are not applicable.
 - b. on primary and secondary structures.
 - c. on soft metals without plain washers.
 - d. on exposed surfaces subject to airflow.

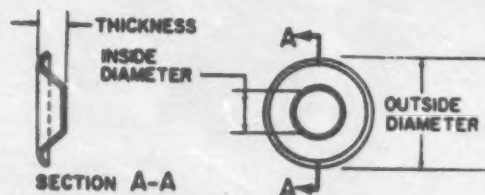
Answers to Frame 25: 1. b, d

Some types of lockwashers have internal or external teeth. The teeth are twisted slightly to provide a locking effect when tightened.

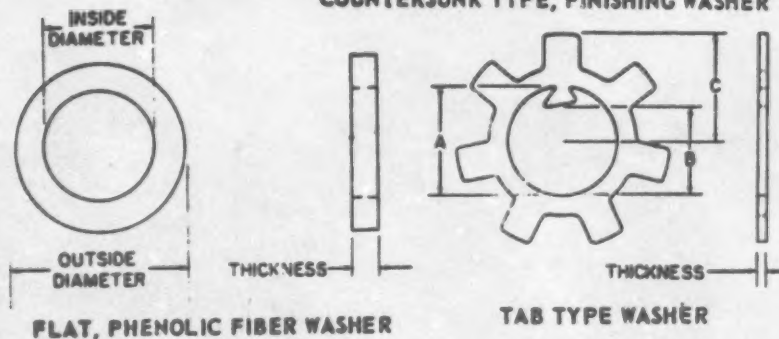


LOCKWASHER

There are many types of special washers, used in various applications. Some special washers are shown in the diagrams below. These are finishing washers, phenolic fiber washers and tab type washers. On the tab type washer one or more of the tabs are bent up against the tightened nut to prevent it from loosening.



COUNTERSUNK TYPE, FINISHING WASHER



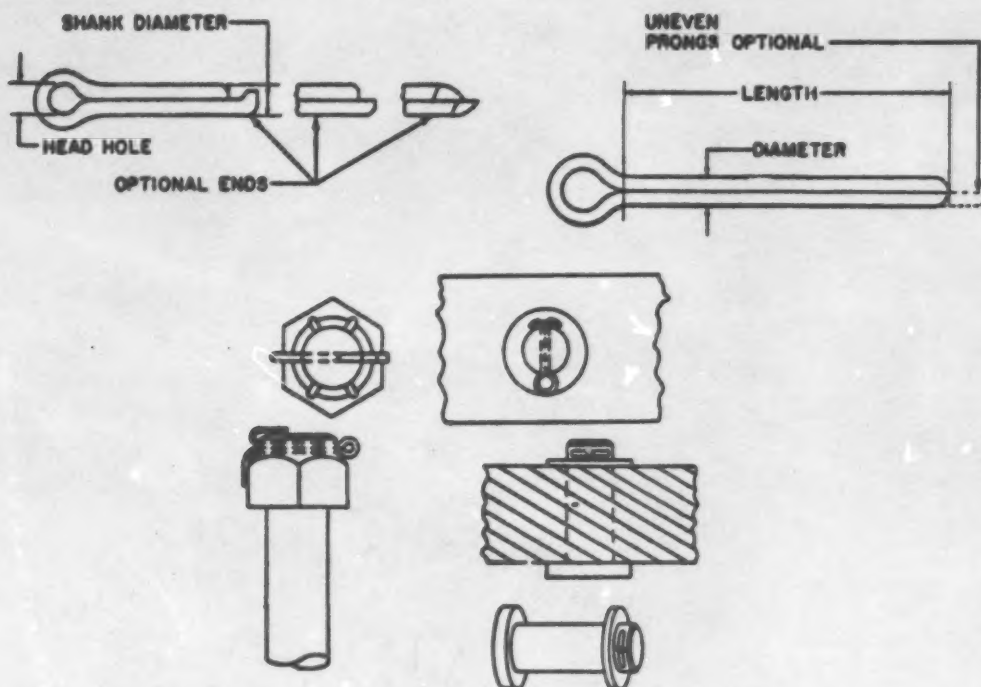
FLAT, PHENOLIC FIBER WASHER

TAB TYPE WASHER

NO RESPONSE REQUIRED

Answer to Frame 26: 1. a

Cotter pins are used to secure bolts, screws, castellated nuts, and pins. A cotter pin is a "split" metal pin that is put in a hole and then spread apart, one half each way. Cotter pins are used for they can be removed and installed quickly. Cotter pins are made in various lengths and diameters. The size of a pin should be the largest size that will fit in a cotter pin hole and/or the slots in a nut. The following diagrams show some of the types of cotter pins and methods of securing them.

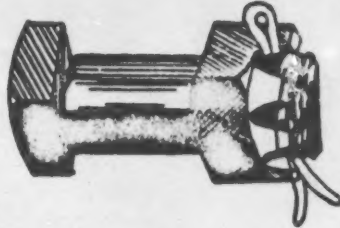


Securing With Cotter Pins

Answer to Frame 27: None Required

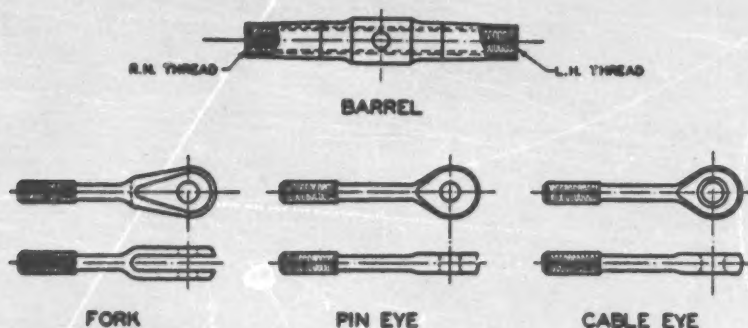
Answer the question.

1. What is the purpose of the cotter pin installed as shown in the diagram below?



- a. To keep the nut from wobbling and thereby ruining the nut threads.
- b. To hold the bolt in place.
- c. To keep the nut from damaging the bolt threads.
- d. To keep the nut from loosening.

The turnbuckle used to adjust the tension on aircraft cables. It has a brass barrel with right-hand threads in one end and left-hand threads in the other. The three types of turnbuckle ends are: fork, pin eye, and cable eye. These parts are shown below. Take a look at them. With the left and right-hand threads in the barrel, turning the barrel one way will tighten both ends and the other way will loosen both ends.



Match the letters to the names on the left.

1. Barrel.
2. Fork End.
3. Cable Eye End.



Answer the question.

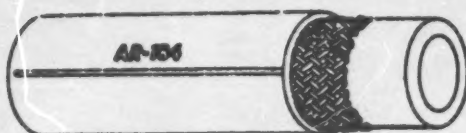
4. What is the designed use of a turnbuckle?
 - a. Holds two pieces of metal securely together.
 - b. Used to safety a cable connection.
 - c. To determine if a bolt has left or right-hand threads.
 - d. Used to adjust cable tension.

Answer to Frame 28: 1. d

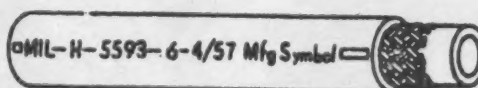
Flexible hose and flexible hose assemblies are used when there is an excessive amount of vibration. They are also used when the units they connect moves during flight.

Flexible hose is marked with a series of dots, dashes and letters (as shown below). These markings are used for identification. The markings are color coded to show different types of hose. The markings on the hose show several things: manufacturer, the military specification, the size, and the date it was made. The size of the hose is the inside diameter measured in sixteenths of an inch. The manufacture date is shown by the quarter of the year and year the hose was made.

RED NUMERALS, LETTERS AND STRIPE



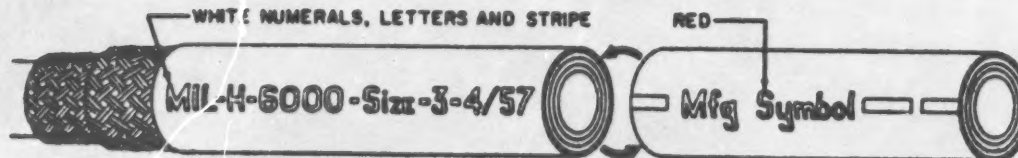
Self-Sealing, Aromatic-Resistant Hose.



YELLOW NUMERALS, LETTERS AND STRIPE

Nonself-Sealing, Aromatic-Resistant
Hose, Military Specification MIL-H-5593
(NOT HEAT RESISTANT)

WHITE NUMERALS, LETTERS AND STRIPE



(VIEWS SHOWING OPPOSITE SIDES OF HOSE)

Nonself-Sealing, Aromatic- and Heat-Resistant Hose, Military Specification MIL-H-6000

NO RESPONSE REQUIRED

Answers to Frame 29: 1. b, 2. c, 3. a, 4. d

Like the flexible hose, tubing is measured in sixteenths of an inch. However, tubing is measured on the outside diameter. If a tube is $\frac{1}{2}$ inch in diameter it would be referred to as a number 8 tube. This is because $\frac{1}{2}$ inch is 8 sixteenths of an inch. Tubing size varies from $\frac{1}{8}$ inch to $2 \frac{1}{4}$ inches. This is shown as a number 2 to a number 36.

Is the following statement TRUE or FALSE?

1. A number 6 fitting would be used with $\frac{3}{8}$ inch OD tubing.

Answer to Frame 30: None Required

2013
Frame 32

The tubing used in aircraft systems is made of aluminum alloy. Aluminum tubing is light and can be formed and bent easily; therefore, care must be taken in handling it so that it will not be damaged. Corrosion resistant steel tubing, is stronger but not as easily formed, is used on hydraulic systems operating at 3,000 psi or higher.

Tubing size is found by measuring the outside diameter (OD) in sixteenths of an inch. The top half of the fraction is the tubing size number. Example: A 1 inch OD tube is called number 16 tubing. $1" = 16/16\text{ths} = \#16$ tubing. $7/8$ inch tubing is number 14 tubing $7/8" = 14/16\text{ths} = \#14$ tubing.

Match each size tubing the outside diameter measurement on the right.

- | | |
|---------------------|--------------|
| 1. Number 4 tubing | a. $5/8"$ OD |
| 2. Number 6 tubing | b. $1/4"$ OD |
| 3. Number 8 tubing | c. $1/2"$ OD |
| 4. Number 10 tubing | d. $3/4"$ OD |
| 5. Number 12 tubing | e. $3/8"$ OD |

Frame 33

Match the outside diameter measurements on the left with the tubing sizes on the right.

- | | |
|------------------------|--------------------------|
| 1. $1\ 1/2"$ OD tubing | a. Number 1 $1/2$ tubing |
| 2. $1\ 1/4"$ OD tubing | b. Number 16 tubing |
| | c. Number 1 $1/4$ tubing |
| | d. Number 20 tubing |
| | e. Number 24 tubing |

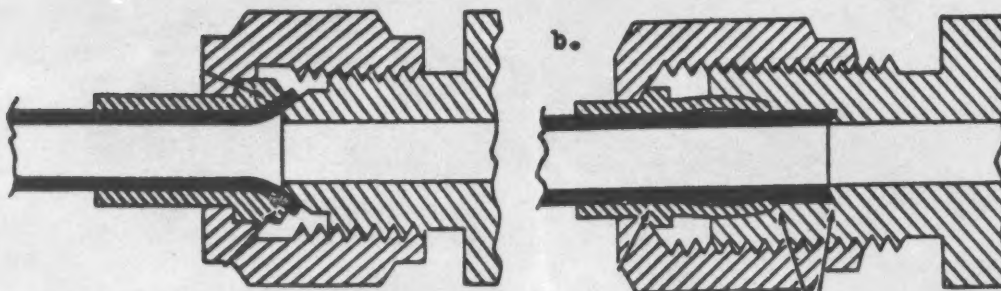
Answer to Frame 31: 1. TRUE

The size of a fitting is determined by the outside diameter of the tubing to which it connects.

The Air Force uses two types of fittings with tubing: AN FLARE fittings, and MS FLARELESS fittings. AN fittings have a sleeve with a beveled edge to fit the flare of the tubing and to form a seal when the tubing nut is drawn tight. Tubing used with MS fittings is not flared. When the tubing nut is tightened on an MS fitting the sleeve is wedged between the tubing and the fitting to form a seal. The torque on MS fittings is critical. Too much torque will cause them to leak.

Match the two illustrations with the correct name.

1. AN fitting.
2. MS fitting.



Answer the questions.

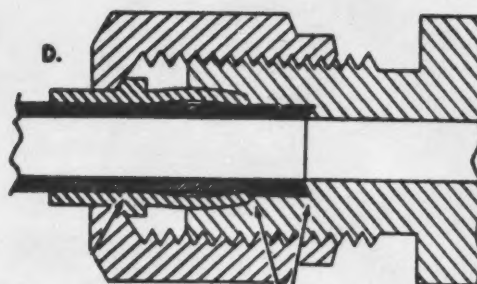
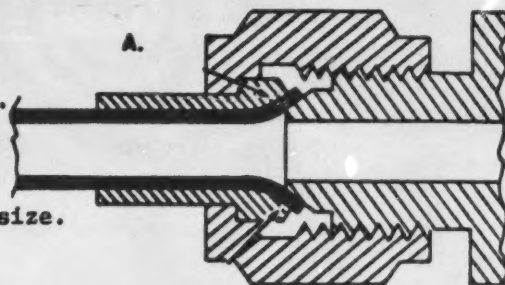
3. What type fitting is used with tubing that is not flared?
 - a. AN fitting
 - b. MS fitting
 - c. Both
 - d. Neither
4. What type fitting is used with flared tubing?
 - a. AN fitting
 - b. MS fitting
 - c. Both
 - d. Neither

Answers to Frame 32: 1. b, 2. e, 3. c, 4. a, 5. d

Answers to Frame 33: 1. e, 2. d

Match the illustrations with the correct uses.

5. Used when tubing is not flared.
6. Connects different sized tubing.
7. Used with flared tubing.
8. Connects two tubes of the same size.



Frame 35

Fitting types and material are identified by color. Aluminum AN fittings are blue. Steel AN fittings are black. Aluminum MS fittings are gray or light yellow. Steel MS fittings are dark yellow. These fittings are not interchangeable. Steel fittings are used for high pressure where aluminum fittings will not hold. AN fittings must have flared tubing while MS fittings will not fit flared tubing.

Match the identifying color with each type fitting.

- | | |
|-------------------------|-------------------------|
| 1. MS aluminum fitting. | a. Dark yellow |
| 2. AN aluminum fitting. | b. Blue |
| 3. MS steel fitting. | c. Gray or light yellow |
| 4. AN steel fitting. | d. Silver |
| | e. Black |

Match the information below.

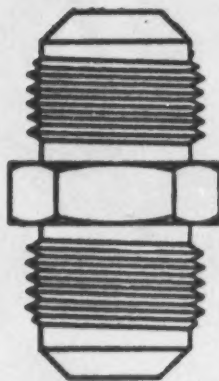
- | | |
|--|---------------|
| 1. Connects different sized tubing. | a. Reducer |
| 2. Used where tubing is flared. | b. Union |
| 3. Connects two pieces of the same size tubing | c. MS fitting |
| 4. Used with flareless tubing. | d. AN fitting |

Frame 37

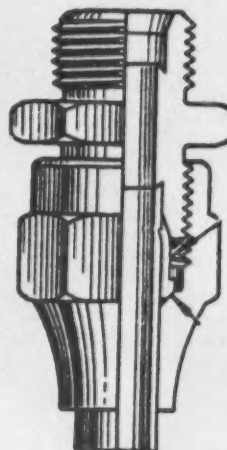
Match the illustrations to their names.

1. AN fitting.
2. MS fitting.
3. Union.
4. Reducer.

a.



b.



c.

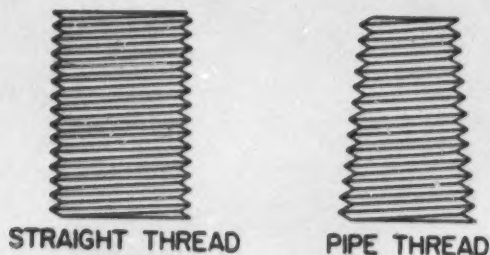


Answers to Frame 34: 1. a, 2. b, 3. b, 4. a, 5. d,
6. c, 7. a, 8. b

Answers to Frame 35: 1. c, 2. b, 3. a, 4. e

AN standard fittings should be used in preference to all other flared fittings. Fitting sizes must match to the size of tubing they are used with. Tubing fittings have either tapered pipe threads or straight threads. Pipe thread fittings are made in a cone shape. Straight threads are the same in diameter the entire length of the threads.

The hole the pipe thread fitting goes into is tapered like the fitting. As the pipe thread fitting is screwed in, its threads seal against the threads of the hole.



NO RESPONSE REQUIRED

Answers to Frame 36: 1. a, 2. d, 3. b, 4. c

Answers to Frame 37: 1. a, 2. b, 3. a, 4. c

Fitting types and materials are identified by color. AN aluminum fittings are blue. AN steel fittings are black. Aluminum bronze fittings are cadmium plated and are not otherwise colored. These fittings are not interchangeable, because if two dissimilar (unlike) metals are brought together they will corrode. Corrosion can cause a potential fire hazard in the presence of oxygen, or a weakness in the metal.

Match the identifying color with each type of fitting.

- | | |
|-------------------------|-------------------------|
| 1. AN aluminum fitting. | a. Dark yellow |
| 2. AN steel fitting. | b. Blue |
| | c. Gray or light yellow |
| | d. Silver |
| | e. Black |

Answer to Frame 38: None Required

A flare and a sleeve, with a nut, are used when connecting straight threads to tubing. The sleeve is used to seal the tubing to the nut and to the fitting. The nut, of course, is used to connect the tubing to the fitting. The nipple is used to connect a piece of tubing to a device having pipe threads.

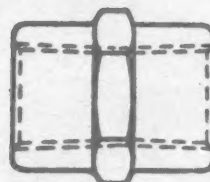
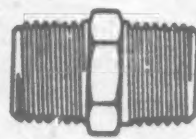


The flared tubing fittings most commonly used in the tubing systems of aircraft is the coupling nut and sleeve.

NO RESPONSE REQUIRED

Answers to Frame 39: 1. b, 2. e

Match the fittings to the descriptions.

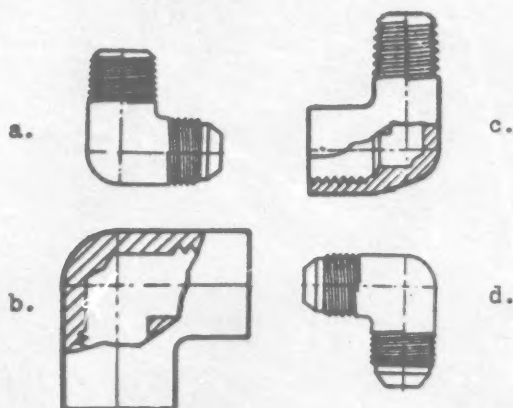


1. Nipple, flared tubing to pipe.
2. Nipple, pipe thread on both ends.
3. Union, flared tube.
4. Coupling, internal pipe thread.

Answer to Frame 40: None Required

In this and the following frames you will be shown various AN fittings. You may well encounter these fittings at a later time in the performance of your job. Study the illustrations carefully. Then you will demonstrate your ability to identify these fittings. Let's see how well you do with the following.

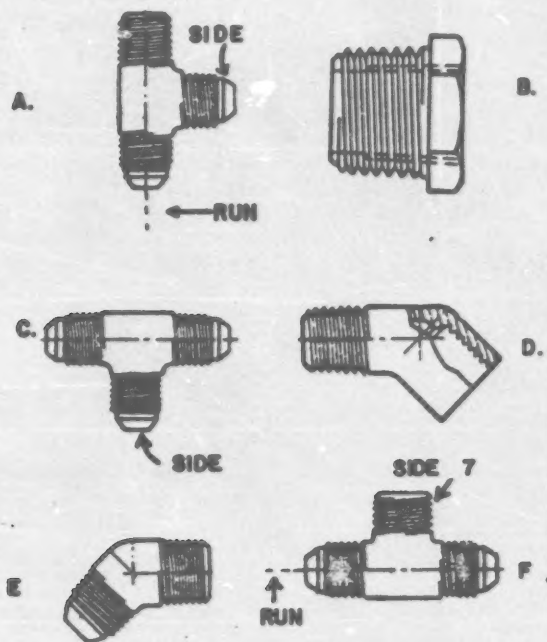
Match the fittings to the descriptions.



1. Elbow, 90° flared tube.
2. Elbow, 90° internal and external pipe threads.
3. Elbow, 90° internal pipe threads.
4. Elbow, 90° flared tube to pipe.

Answers to Frame 41: 1. c, 2. b, 3. a, 4. d

Match the illustrations with their correct descriptions.



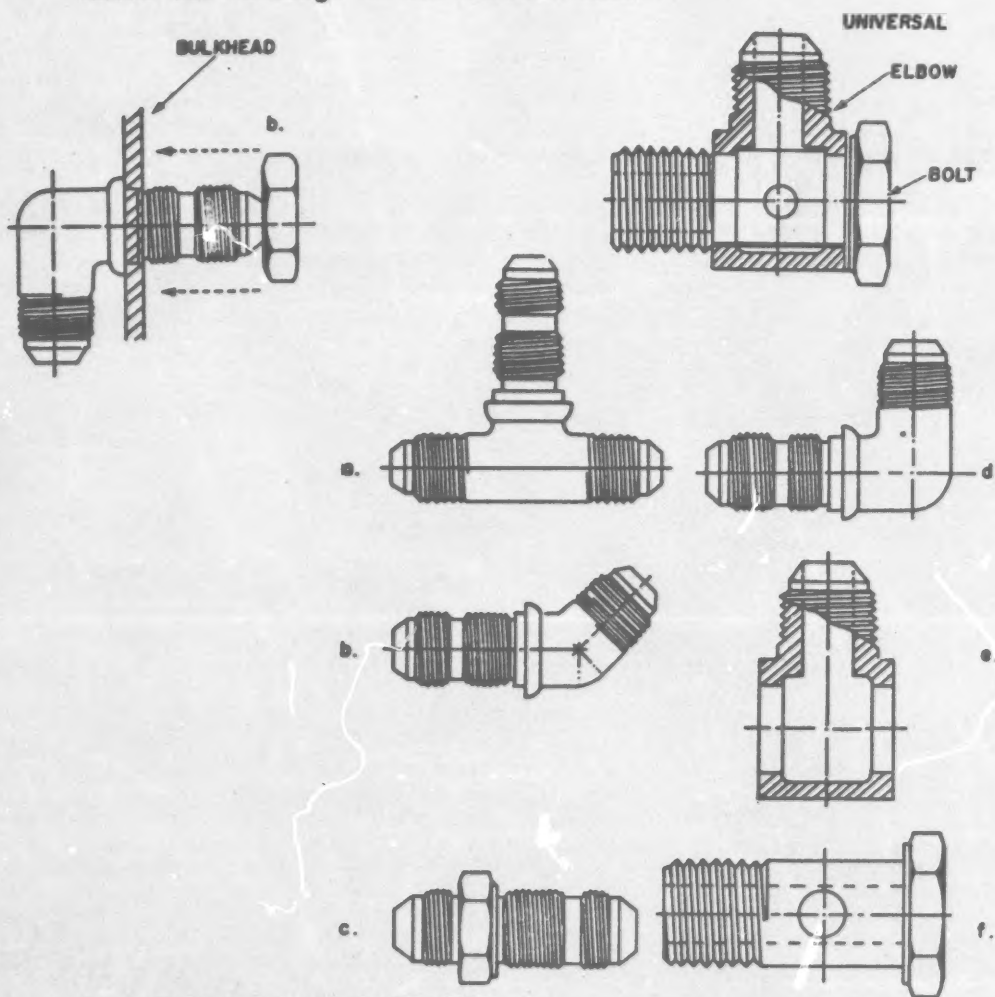
1. Bushing, reducer.
2. Tee, flared tube.
3. Elbow 45° internal and external pipe threads.
4. Tee, flared tube, pipe thread on side.
5. Elbow 45° flared tube to pipe.
6. Tee, flared tube, pipe thread on the run.

Answers to Frame 42: 1. d, 2. c, 3. b, 4. a

Bulkhead and universal fitting combinations can be mounted, solidly to a bulkhead or component with one outlet adjusted to any angle. "Bulkhead" means that the fitting is long enough to go through a bulkhead. "Universal" means that the fitting can be set at any angle, using a universal fitting bolt.

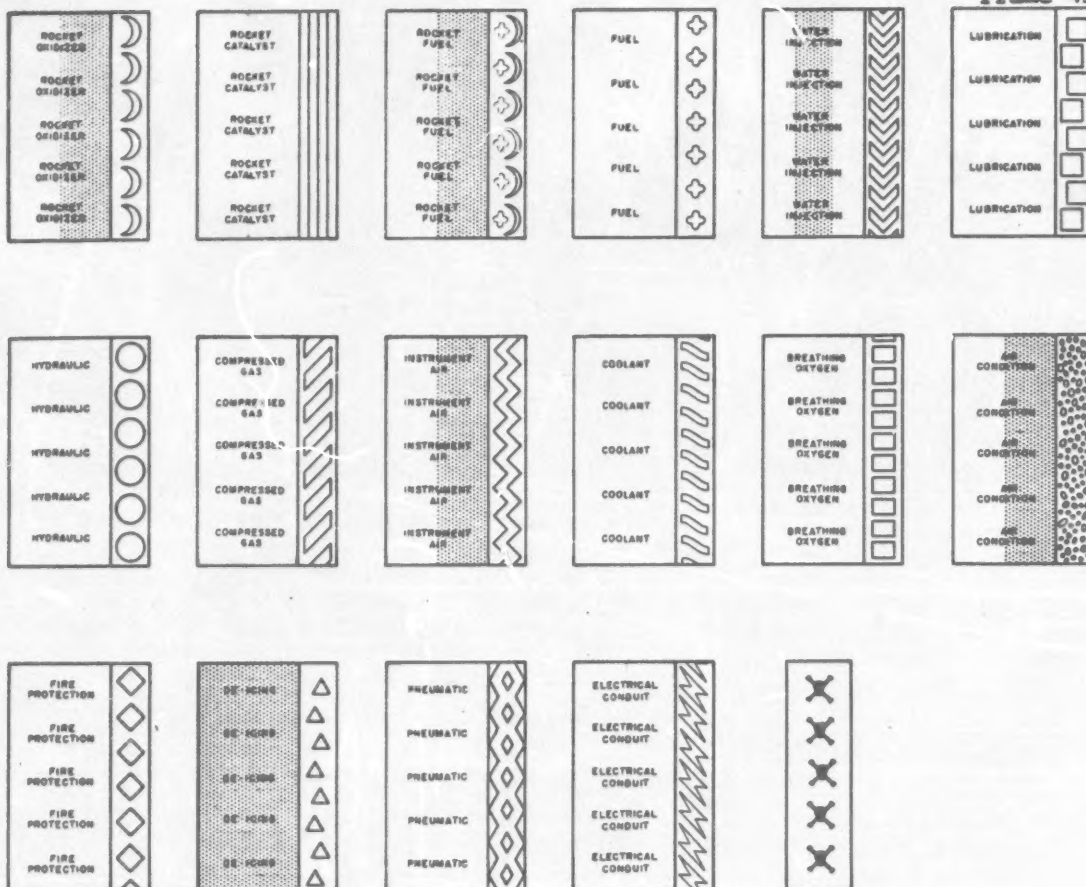
When installing a bulkhead fitting, a jam nut is used to hold the fitting securely in the bulkhead. This is shown in the following illustration. Fittings with evidence of visible damage, (stripped threads, deep gouges and nicks, wrench jaw marks, etc) will be replaced.

Match the fittings to the correct name.



1. Bolt, universal fitting.
2. Tee, flared tube, bulkhead.
3. Elbow 90°, flared tube, bulkhead.
4. Union, flared tube, extra length, for mounting in a bulkhead.
5. Elbow, 90° universal.
6. Elbow, 45°.

Answers to Frame 43: 1. b, 2. c, 3. d, 4. f, 5. e,
6. a



Code bands of varicolored tape are attached to the tubing throughout the aircraft. These bands are placed near the joints and quickly identify the content and danger when working on or around these tubing.

A chart showing some of the color coding for tubing systems is shown above. This chart can be found in the appropriate technical orders.

Match the color code to the systems listed below.

- | | |
|----------------------|----------------|
| 1. Fire protection. | a. Gray |
| 2. Lubrication | b. Blue-yellow |
| 3. Breathing oxygen. | c. Brown-gray |
| 4. Fuel | d. Green |
| 5. Air condition. | e. Yellow |
| 6. Pneumatic. | f. Red |
| 7. Hydraulic. | g. Brown |
| 8. De-icing | h. Red-blue |

Answers to Frame 44: 1. f, 2. a, 3. d, 4. c, 5. e, 6. b

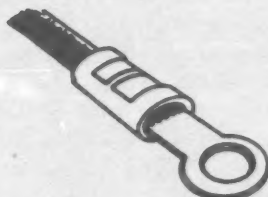
Answer the statements as true (T) or false (F).

1. The two most common types of tubing used in aircraft systems lines are corrosion-resistant aluminum alloy and copper.
2. Aluminum alloy tubing is most widely used in low and medium pressure systems.
3. The color code which identifies the contents of the system as breathing oxygen is red.
4. Stainless steel tubing is used in high-pressure systems.

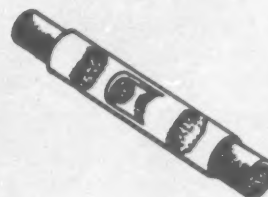
Answers to Frame 45: 1. g, 2. e, 3. d, 4. f, 5. c,
6. h, 7. b, 8. a

Solderless terminal lug (A) permit easy and efficient connection and disconnection of wire from electrical equipment. Solderless splices (B) join electrical wires to form permanent continuous runs. These terminal lugs and splices come preinsulated (A) or uninsulated (B). They are made of copper or aluminum.

Note: Copper wire requires copper connectors and the aluminum wire requires aluminum connectors.



"A"



"B"

Select the correct statement(s).

1. To join electrical wires to form a continuous run, solderless terminal lugs are used.
2. Solderless terminal lugs permit easy disconnection and connection to electrical equipment.
3. Solderless terminal lugs and solderless splices may be uninsulated or preinsulated.

Answers to Frame 46: 1. F, 2. T, 3. T, 4. F

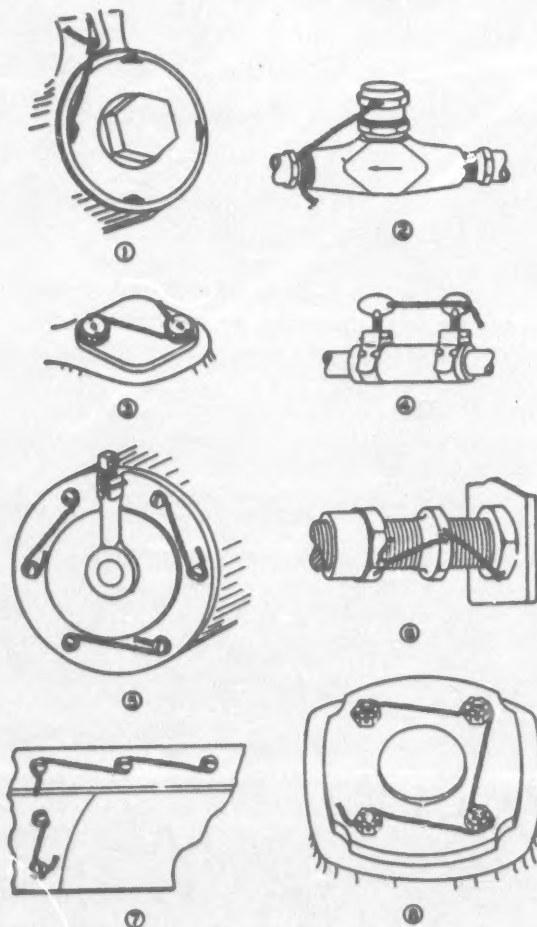
Aircraft vibration does tend to loosen or alter the adjustment of various parts. These parts are safetied by an auxiliary device, such as safety wire.

Safety wire is made of copper, aluminum or steel. Copper wire (.020-inch diameter), is used for safetying seals on equipment such as first aid kits and portable fire extinguishers.

Aluminum wire (.032-inch diameter) is used for safetying emergency valves or oxygen regulators. BE SURE TO CONSULT THE SPECIFIC TECHNICAL ORDER AND USE THE WIRE SIZE REQUIRED.

Some emergency devices use a safety or shear wire. Care must be used to be sure that the use of safety wire will not stop the emergency operation of the device.

The illustrations shown are typical examples of proper safety wire installations. Study these illustrations. Notice the proper way to install safety wire for a given situation.



NO RESPONSE REQUIRED

Answers to Frame 47: 1. F, 2. T, 3. T
54

Two methods of safety wiring are used: the single-wire method and the double-twist method. The single-wire method is used on emergency devices. The single-wire method is also used in areas hard to-reach and for small screws in a closely spaced pattern.

The double-twist method is the most common method used. The most common sizes of safety wire in use are .020 inch and .032 inch.

Complete the statement.

1. The two sizes of safety wire most commonly used to safety parts, using the double-twist method, are
 - a. .032-inch and .037-inch.
 - b. .020-inch and .037-inch.
 - c. .041-inch and .047-inch.
 - d. .020-inch and .032-inch.

Answer to Frame 48: None Required

The number of bolts, nuts, screws, etc, that may be wired together depends upon the application. When the double-twist method is used, the maximum number of wider spaced bolts that can be wired in a series is three. The number of closely spaced bolts, that can be wired by a 24-inch length of wire is the maximum number in a series.

Complete the statement.

1. The maximum number of widely spaced bolts which may be wired in a series is
 - a. 1.
 - b. 2.
 - c. 3.
 - d. 4.

Answer to Frame 49: 1. d

C The correct procedure for safety wiring will be explained in the safety wiring project. In that project, you will learn the proper method by actually doing the job.

6 Answer to Frame 50: 1. c

Caution: TO BE USED BY THE PNEUDRAULIC COURSE ONLY.

Frame 51

Note: To complete this terminal frame you must have a hardware trainer.

Match the names listed below with the correct item on the trainer. Place the number on the trainer that corresponds to the item you selected on the separate answer sheet. Some items on the trainer are not in this list.

- | | |
|-----------------------------------|----------------------------------|
| 2. Bolt, clevis. | 22. Elbow 90°, bulkhead. |
| 3. Bolt, hex head steel. | 23. Union MS. |
| 4. Cotter pin. | 24. Tee fitting. |
| 5. Eyebolt. | 25. Nipple, flared tube to pipe. |
| 6. Machine screw, flathead. | 26. Elbow 90°, pipe to tube. |
| 7. Screw, Reed and Prince head. | |
| 8. Reducer steel. | |
| 9. Machine screw, fillister head. | |
| 10. Plate nut. | |
| 11. Cross fitting steel. | |
| 12. Wing nut. | |
| 13. Nut, plain steel. | |
| 14. Screw, Phillips head. | |
| 15. Nut, castellated steel. | |
| 16. Bolt, drilled head steel. | |
| 17. Tee fitting bulkhead. | |
| 18. Nut, self-locking aluminum. | |
| 19. Nut steel self-locking. | |
| 20. Sleeve. | |

Answers to Frame 51:

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1. 29.
2. 6.
8. 8.
4. 17.
5. 12.
6. 23.
7. 22 or 23.
8. 47.
9. 14.
10. 20.
11. 44.
12. 21.
13. 41.
14. 14.
15. 27.
16. 8.
17. 36.
18. 28.
19. 25.
20. 39.
21. 51.
22. 46.
23. 18.
24. 45.
25. 42.
26. 53.

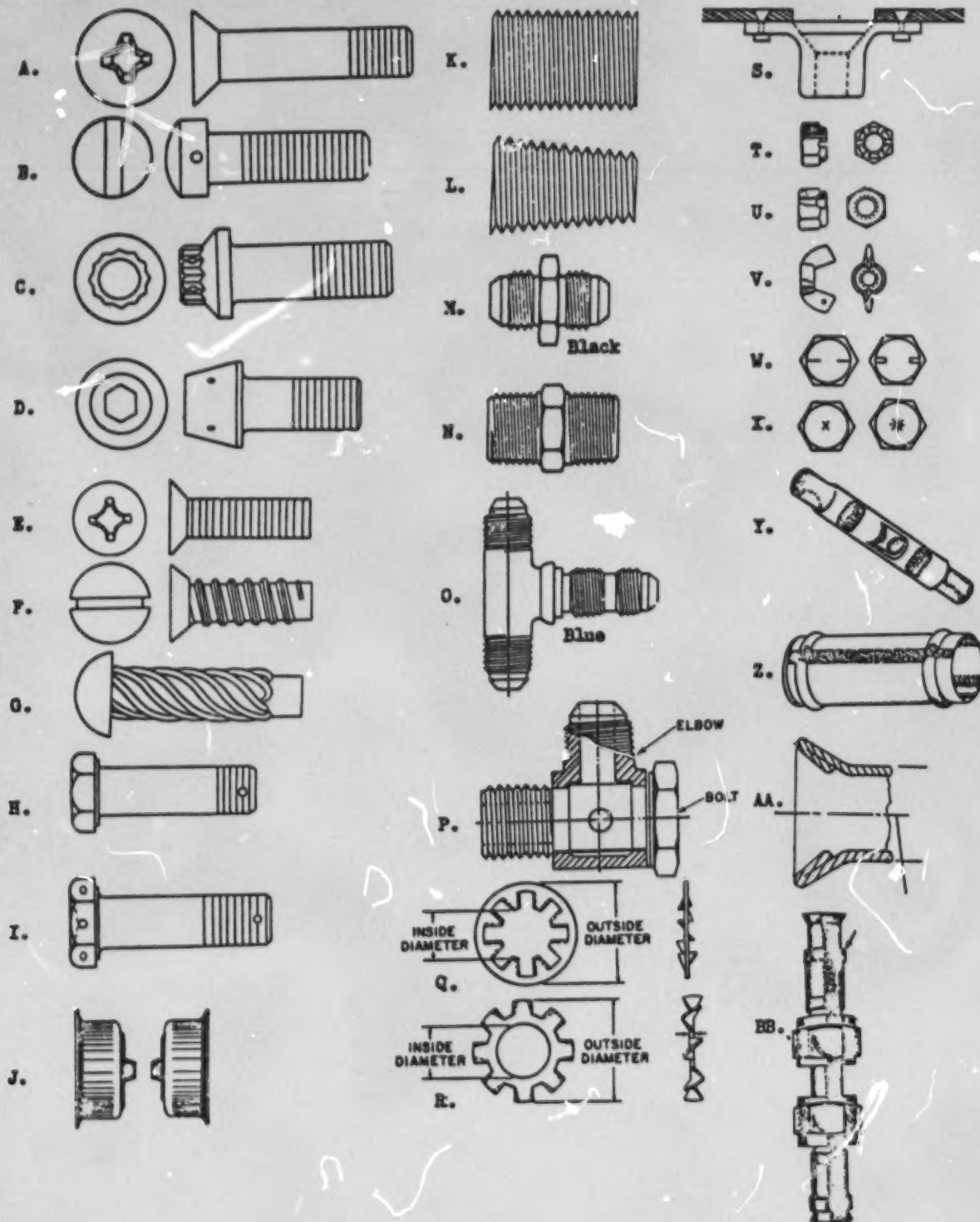
Frame 51A

Note: To complete this frame you must have a hardware trainer.

Match the names listed below with the correct item on the trainer. Place the trainer number that corresponds with that item on the separate answer sheet. Some items on the trainer are not listed.

- | | |
|------------------------------------|--------------------------------------|
| 1. Wood washer. | 21. Splice. |
| 2. Bolt, clevis. | 22. Elbow 90°, bulkhead. |
| 3. Bolt, hex head steel. | 23. Tinnerman nut. |
| 4. Cotten pin. | 24. Tee fitting. |
| 5. Ey bolt. | 25. Cross fitting, internal threads. |
| 6. Machine screw, flathead. | 26. Elbow 90°, pipe to tube. |
| 7. Screw, Reed and Prince head. | |
| 8. Lock washer. | |
| 9. Machine screw, roundhead. | |
| 10. Plate nut. | |
| 11. Machine screw, Fillister head. | |
| 12. Wing nut. | |
| 13. Nut, plain steel. | |
| 14. Screw, Phillips head. | |
| 15. Nut, castellated steel. | |
| 16. Bolt, drilled head steel. | |
| 17. Screw, sheetmetal. | |
| 18. Nut, self-locking aluminum. | |
| 19. Nut, steel self-locking. | |
| 20. Dzus stud. | |

1. 11.
2. 1.
3. 5.
4. 12.
5. 7.
6. 10.
7. 18.
8. 24.
9. 9.
10. 15.
11. 4.
12. 16.
13. 21.
14. 17.
15. 22.
16. 3.
17. 13.
18. 20.
19. 23.
20. 29.
21. 33.
22. 40.
23. 32.
24. 39.
25. 36.
26. 47.



Match the names below with the correct item on the opposite page. Place the capital letter that corresponds with that item on the separate answer sheet. Some items are not listed.

2. Bolt, hex head aluminum.
3. Bolt, hex head steel.
4. Pipe thread (basic design).
5. Bolt, internal wrenching.
6. Screw, machine flathead.
7. Universal fitting combinations.
8. Lock washer, internal.
9. Tube, beaded end.
10. Nut, plate.
11. Screw, machine Fillister head.
12. Nut, wing.
13. Shock mount.
14. Screw, crosspoint.
15. Nut, castle.
16. Bolt, drilled hex head.
17. Screw, sheet metal (self-tapping).
18. Nut, fiber self-locking.
19. Joint (section) flared tubing.
20. Tube, double-flared.
21. Splice, solderless.
22. Tee, flared tube, bulkhead.
23. Steel flared fitting.
24. Nipple, pipe thread.

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Answers to Frame 51B:

1. G .
2. W.
3. X.
4. L.
5. D.
6. A or E.
7. P.
8. Q.
9. Z.
10. S.
11. B.
12. V.
13. J.
14. A or E.
15. T.
16. I.
17. F.
18. U.
19. BB.
20. AA.
21. Y.
22. O.
23. M.
24. N.

**Technical Training**

**Aircraft Environmental Systems Mechanic
Aircraft Pneudraulic Mechanic**

SAFETYING METHODS, PROCEDURES, AND DEVICES

18 February 1975



CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes ST 3ABR42231-WB-303A, 19 July 1973.

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SAFETYING METHODS, PROCEDURES, AND DEVICES

OBJECTIVES

After completing this workbook, you will be able to safety an assortment of aircraft hardware on a safetywire trainer. To enable you to do this, you will be required to:

1. Identify methods of safetying.
2. Follow proper safetying procedures.
3. Use mechanical safetying devices.

Standard of Performance

You will be evaluated by an instructor who will observe your performance and administer a criterion referenced test. You must complete this project with 70% accuracy.

EQUIPMENT

Safetywire Trainer (2301 Environmental)	Basis of Issue
(4183 Pseudraulic)	1/student
Applicable Handtools	1/student
Safetywire	1/student
Cotter Pins	1/student

PROCEDURE

There are several methods used to safety aircraft hardware. We wish we could familiarize you with all of them. Since we don't have that much time, we will concentrate on the safetying methods most common to your job.

Follow each part of this workbook closely. Perform each step carefully. Be particularly careful with the sharp ends that are created when safetywire and/or cotter pins are cut.

You will need certain handtools to accomplish the tasks listed in this workbook. Ask the instructor where you may obtain these tools.

Sidecutters (diagonal cutters)
Pliers (duckbill or suitable substitute)
Safetywire Pliers

SECTION I. METHODS OF SAFETYING

I. Securing with Cotter Pins.

A. Cotter pins are used to secure such items as bolts, screws, pins, castellated nuts, and shafts.

B. The use of cotter pins is favorable because they can be installed and removed quickly.

II. Securing with Safetywire.

A. Single Wire Method.

1. This method is used to safety closely spaced fillister head screws (screws with holes drilled through the head) in a closed geometrical pattern.

2. The wire is installed so that the screws cannot loosen.

3. Always use the largest size wire that the hole will accomodate.

B. Double Twist Method.

1. This is the most common method of safetywiring used.

2. The double twist method can be used to safety bolts, nuts, and screws.

a. If parts are closely grouped, it is more convenient to safetywire them to each other. This is called series.

b. The maximum number of bolts that can be wired in a series is three.

c. The maximum length of wire that can be used is 24 inches.

d. Bolts, nuts, and screws which are spaced more than 6 inches apart shall not be wired in series, but safetied individually.

SECTION II. SAFETYING PROCEDURES

I. Using Cotter Pins.

A. In the lower left corner of the safetywire trainer is a castle nut for you to secure.

B. Refer to figure 1 for correct installation of the pin and perform the following steps.



Figure 1. Cotter Pin Installation.

1. If the castle nut is loose ask the instructor for a wrench to tighten it. Align the nut so that a cotter pin will pass through it and the hole in the bolt.
2. Select the largest size cotter pin that the hole will accomodate.
3. Push the cotter pin through the hole in the bolt as far as it will go. The long side of the cotter pin should be up.
4. With the sidecutters, bend the long side of the cotter pin straight up. Cut it off so that it resembles the pin shown in figure 1. CAUTION: Hold your free hand over the nut while cutting the pin so that the snipped end won't fly up and strike you in the eye.
5. Bend the cut side of the cotter pin over the bolt head and tap it flat with the sidecutters.
6. Bend the other side of the cotter pin straight down. Cut it off so that it looks like the pin in figure 1. Tap with the sidecutters until it lies flat against the nut.
7. When you feel that you have properly safetied the castle nut, proceed to the next task.

II. Using Safetywire.

A. Single Wire Method.

1. On the right side of the safetywire trainer there is an electrical connector. The base of the connector is fastened to the trainer board by four fullister head screws.
2. Refer to figure 2 for correct installation of the wire and perform the following steps.
 - a. Cut a piece of safetywire approximately 12 inches long.
 - b. Thread the wire through the hole in the head of screw number 1 until the ends are about equal in length.

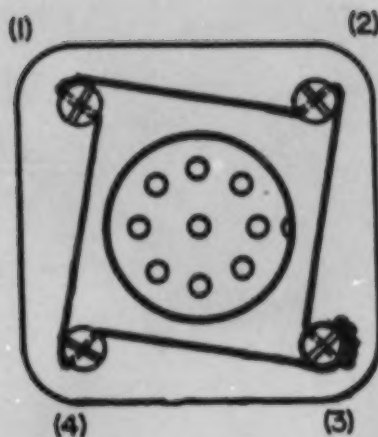


Figure 2. Top View of Connector Plug.

Note: If the hole in the screw is blocked by the body of the connector, the screw may be loosened enough to get the wire through. After the wire has been threaded through the hole, retighten the screw before taking the wire to the next screw.

c. The wire should be threaded through screws 2 and 4 so that if screw number 1 tries to loosen, force will be applied in the tightening direction to these adjoining screws. The same procedure must be used on all four screws.

d. After you have threaded the wire through the hole in screw number 3, use the pliers and twist the ends of the wire together starting at the hole.

e. Cut the wire so that a pigtail about 1/4 to 1/2 inch long remains. Note: The pigtail should contain a minimum of 3 to 6 twists.

f. Bend the pigtail around the screw so that it looks like the wire in figure 2. This will help keep someone from snagging their hand on the safetywire.

g. When you feel that you have properly safetied the four fillister head screws, proceed to the next task.

B. Double Twist Method.

1. Across the top of the safetywire trainer there are four bolt heads in a straight line.

2. Refer to figure 3 for correct installation of the wire. Safety the first two bolt heads from the left by performing the following steps.

- a. If the bolts are loose ask the instructor for a wrench to tighten them.



Figure 3. Boltheads Safetied by the Double Twist Method.

- b. Cut a piece of safetywire approximately 12 inches long.
- c. Thread the wire through the hole in the bolt head until the ends are about equal in length.
- d. The wire may be twisted by hand except for the final few twists which should be made with pliers to properly secure the wire ends.
- e. The wire must be twisted so that the loop around the bolt head stays down. Extreme care should be taken when twisting the wire to insure that it is tight but not stressed to the point where breakage might occur under a slight load or vibration.
- f. Thread the wire through the second bolt head so that if either bolt head tries to loosen (turn counterclockwise), force will be applied in the tightening direction to the other.
- g. Use the pliers to twist the wire counterclockwise.
- h. Cut the wire so that a pigtail about 1/4 to 1/2 inch long remains. Note: The pigtail must contain a minimum of 3 to 6 twists.
- i. Bend the pigtail around the bolt head so that it looks similar to that in figure 3.
- j. If you feel that you have properly safetied the two bolt heads, proceed to the next task.

C. Safetywiring V-Band Clamps.

Note: Pneudraulic repairmen are to skip this portion of the workbook. Go to section III and continue from there.

1. On the safetywire trainer there is a piece of ducting connected by a V-band clamp.
2. Refer to figure 4 for correct installation of the wire and safety the V-band clamp by performing the following steps.

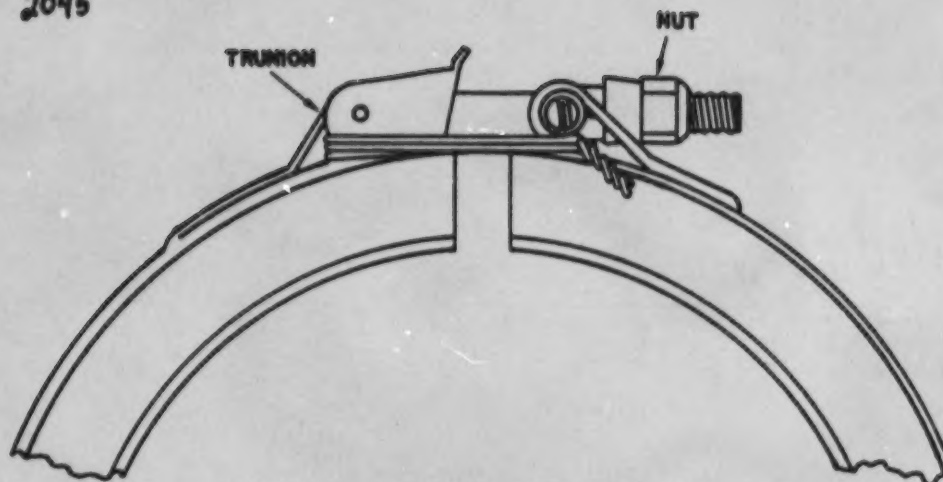


Figure 4. Top View of V-Band Clamp.

- a. Position the trainer so that the clamp looks similar to figure 4.
- b. Make sure the nut which holds the clamp together is tight. On the actual aircraft you would have to check the applicable TO to find what the torque value. We won't have you torque the nut here, just remember that it is torqued.
- c. Cut a piece of safetywire approximately 24 inches long.
- d. Fold the wire in half.
- e. Insert the folded end of the wire through the opening in the left side of the clamp, just to the left of the clamp trunion pin. The wire should be inserted through the opening going from the top and pushed through until about 6 inches of wire protrudes out the other side of the clamp. See figure 5.

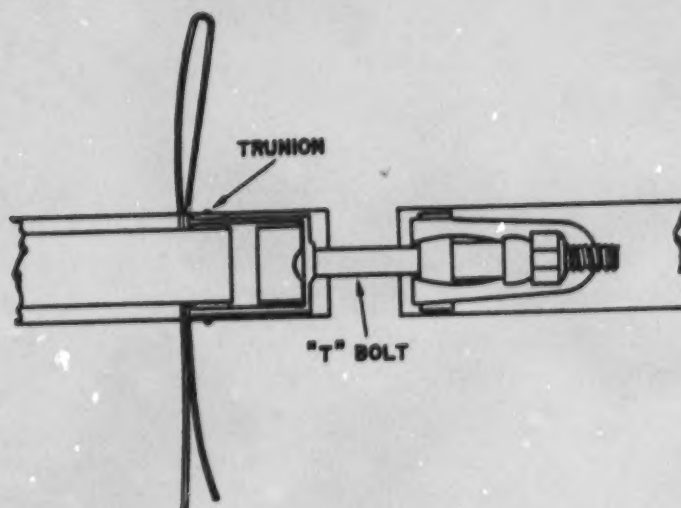


Figure 5. Side View, V-Band Clamp.

f. Bend the lower set of wires to the right and parallel to the "T" bolt. See figure 6.

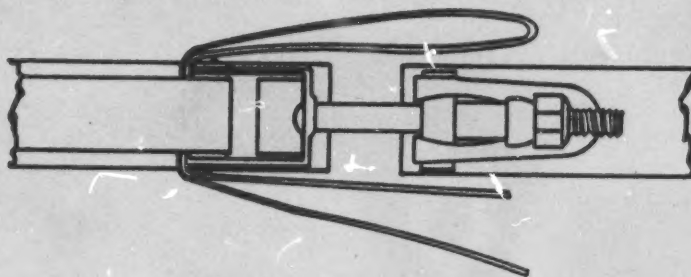


Figure 6. Side View, B-Band Clamp.

g. Bend the upper set of wires to the right and parallel to the "T" bolt. See figure 6 again.

h. Insert the folded end of the wire through the opening on the far right side of the clamp. Pull the wire tight so that the folded end of the wire is straight away from the clamp and towards you. See figure 7.

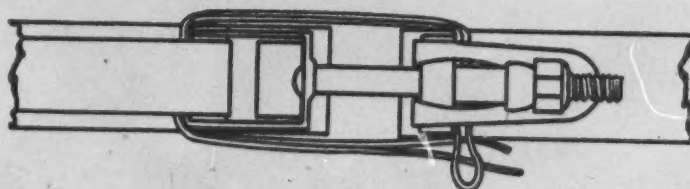


Figure 7. Side View, V-Band Clamp.

i. Twist the two sets of wire together and counterclockwise. Start at the hole on the right side of the clamp. Twist until there is a pigtail containing a minimum of two twists.

j. Bend the pigtail to the right and flat against the clamp; then loop the end of the pigtail back towards the clamp so that it cannot become a dangerous snag. Refer to figure 8 to see how the clamp should appear when properly safetied.

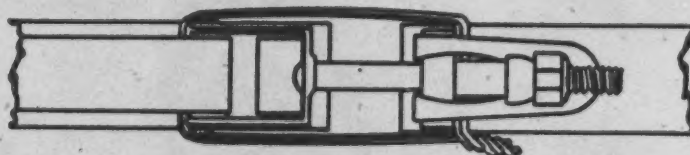


Figure 8. Side View, V-Band Clamp.

k. If you have any questions inform the instructor before you continue with the next section of this booklet.

SECTION III. MECHANICAL SAFETYING DEVICES

I. Using Safetywire Pliers.

A. Safetywire pliers may be used to perform all the mechanical steps of safetywiring. The steps are bending, twisting, and cutting. The flat, rounded nose is used to grip and bend the wire. Just behind the nose is the sidecutter for cutting the wire. The twisting mechanism consists of a lock. The pliers are locked closed on the wire. A ratchet device which causes the pliers to rotate in a clockwise direction when the knob is pulled. See figure 9 for an illustration of the safetywiring pliers.

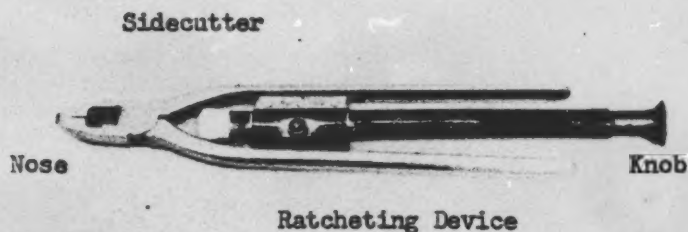


Figure 9. Safetywiring Pliers.

B. In about the center of the safetywire trainer are five bolt heads arranged something like a star. We want you to practice using the safetywiring pliers. Safety the top center bolt head in series with the next two in the clockwise direction.

C. Refer to figures 10 thru 22 and safetywire the three bolt heads by performing the following steps.

1. Make sure the three bolt heads are tight.
2. Cut a piece of safetywire approximately $3 \frac{1}{2}$ times the length of the distance between the three bolt heads. See figure 10. DO NOT EXCEED 24 INCHES. TO 1-1A-8 limits the length of wire to 24 inches when wiring in series.

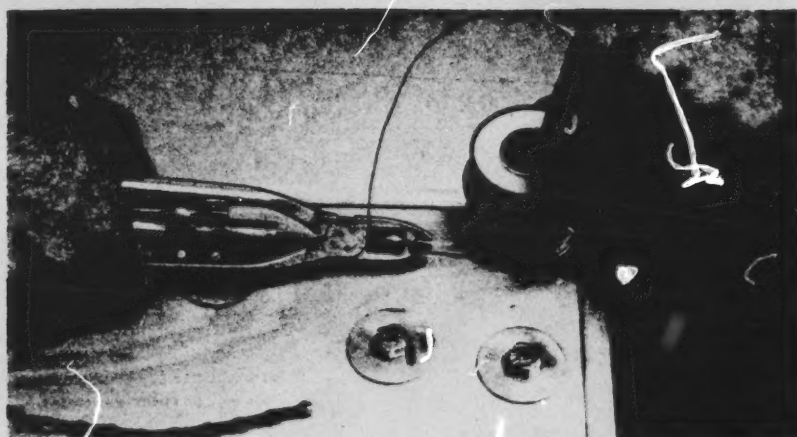


Figure 10. Cutting Wire with Safetywiring Pliers.

3. Thread the wire straight through the hole in the top bolt head until the two wire ends are about equal in length.

4. Pull the left end of the wire around the bolt head in a clockwise direction. Pass it under the right-hand wire. Pull tightly with the safetywire pliers. The wire should conform to the shape of the hexhead bolt.

5. Twist the two wires together by hand. Make sure the first twist begins at the drilled hole. Make about three twists clockwise while pulling firmly. See figure 11 below.

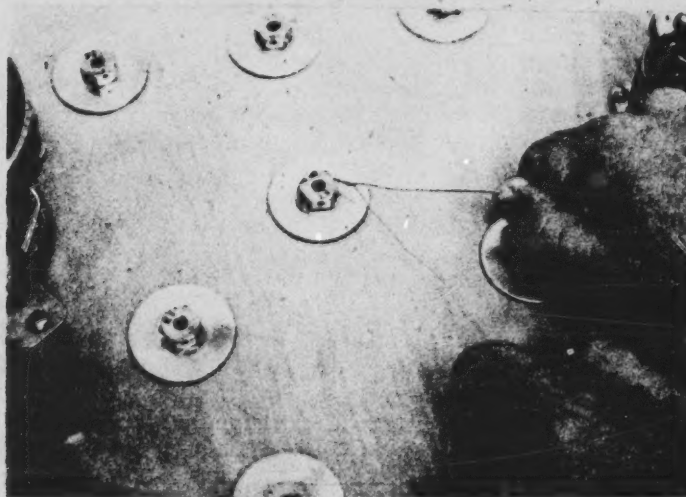


Figure 11. Starting the Twist by Hand.

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6. Grip the two strands of wire with the safetywiring pliers. Grip at a point approximately 1/16 inch longer than the distance to the next bolt head (figure 12). To lock the pliers closed, squeeze the handles together tightly enough so that the locking button can be pushed in. Now, release your grip slightly and the pliers should remain locked.

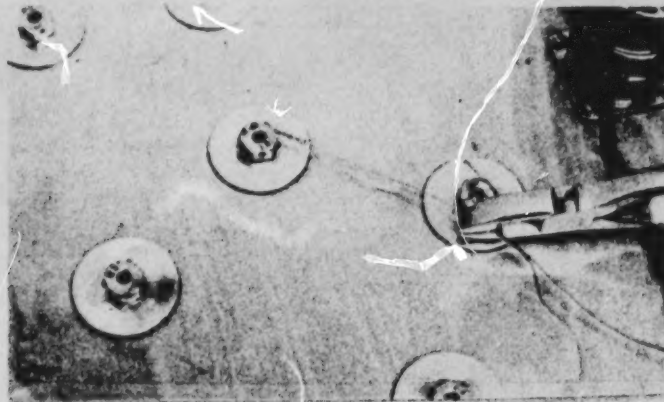


Figure 12. Determine Length of Wire between Bolt heads.

7. Now, let go of the pliers, except at the knob. Hold the pliers up and slightly away from the trainer. Pull the knob to its extended position approximately 6 inches. You may have to pull with both hands.

8. The next step depends on the type of safetywire pliers that you have. Proceed with step a or b as applicable.

a. If you have the one type of pliers the knob returns to its original position automatically. You will have to grasp the handles of the pliers with one hand and release the knob.

b. The other type of pliers has a knob that does not return to its original position automatically. You will have to grasp the handles of the pliers with one hand. Push the knob back to its original position with the other hand.

9. Again, pull the knob. Repeat the applicable procedure 8a or 8b, until the wire is twisted the desired number of twists. Should be about 8 twists per inch.

10. When the desired number of twists per inch is attained, unlock the pliers by gently squeezing the handles together.

11. The twisted wire should now reach the hole in the second bolt head (you may twist or untwist the wire one or two twists by hand until it is the correct length). Now, insert the top wire through the hole as shown in figure 13.



Figure 13. Insert Wire through next Bolt head.

12. Grasp the end of the wire with the safetywire pliers. Pull it through the hole until the twisted part between the two bolt heads is tight (figure 14). CAUTION: Do not allow the wire to kink as you pull it through the hole, don't pull it too tight as it might break.

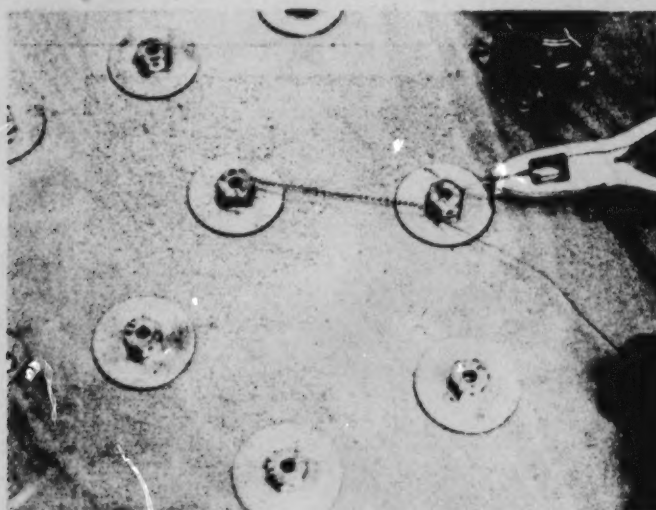


Figure 14. Make sure the Wire is Tight.

13. While keeping tension on the wire extending through the bolt head, pull the other wire around the bolt in a clockwise direction, (figure 15). After the wire is bent around the bolt head, pass it under the wire that extends through the bolt head.

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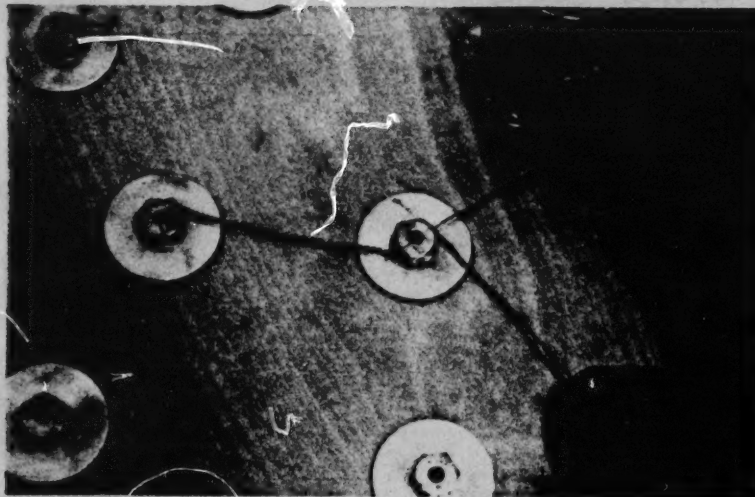


Figure 15. Wire goes around Bolt head in Clockwise Direction.

14. Twist the two wires together by hand. Make sure the first twist begins at the drilled hole. Make about three twists clockwise while pulling firmly on the wire. See figure 16.

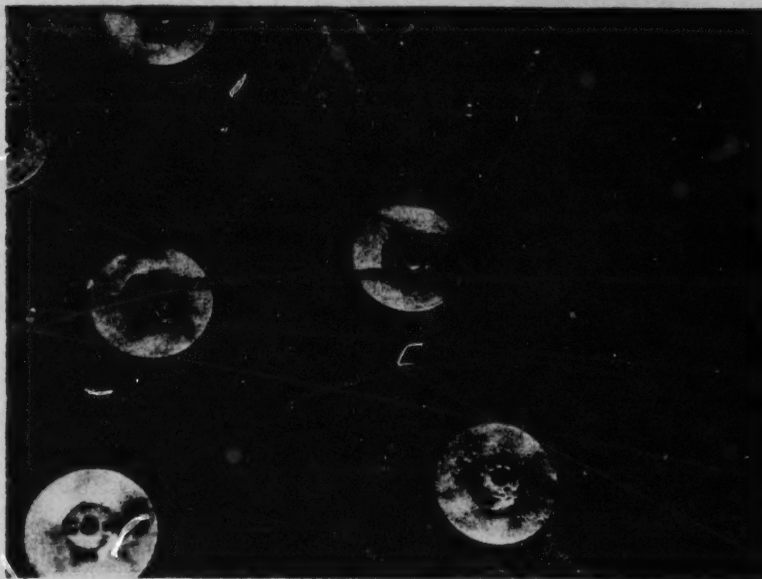


Figure 16. Starting the Twist by Hand.

15. Now, repeat steps 6 thru 10 to arrive at the point shown in figure 17.

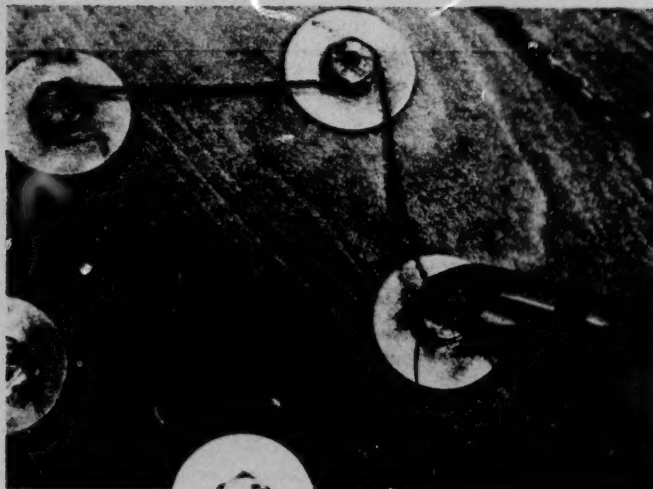


Figure 17. Taking Wire to Next Bolt head.

16. The twisted wire should now reach the hole in the third bolt head. Insert the top wire through the hole in the bolt. Pull it tight with the safetywire pliers as shown in figure 18.

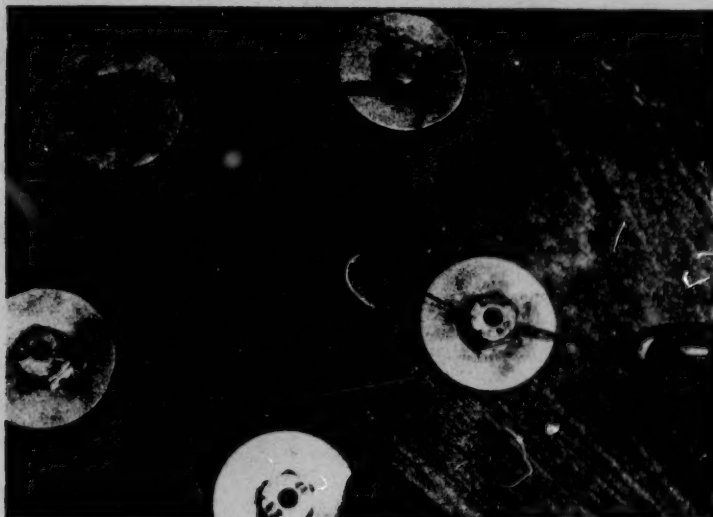


Figure 18. Make sure the Wire is Tight.

17. While keeping tension on the wire extending through the bolt head, pull the other wire around the bolt in a clockwise direction. Pass this wire UNDER the wire which extends through the bolt head. See figure 19 below.



Figure 19. Wire goes Around Bolt head in Clockwise Direction.

18. Twist the two wires together by hand making sure the first twist begins at the hole in the bolt head. Make about five twists clockwise while pulling firmly on the wire.

19. Use the safetywiring pliers for the final twisting. This is to insure the wire is twisted good and tight. This time there should be about 12 to 15 twists per inch. See figure 20.



Figure 20. Forming of Pigtail.

20. Use the safetywiring pliers to cut the twisted wire so that a pigtail $1/4$ to $1/2$ inch long remains. See figure 21.

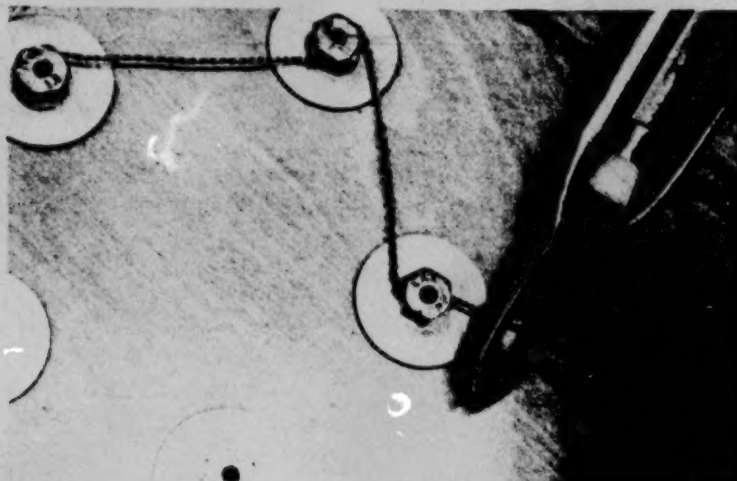


Figure 21. Pigtail $1/4$ to $1/2$ Inch Long.

21. Bend the pigtail into a loop and flat against the bolt head so that it can't become a snag. See figure 22.



Figure 22. Wiring Safety Procedures.

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22. When you feel you have properly safetied the three bolt heads in series, have the instructor check all of your work at one time (the cotter pin, single wire method, double twist method, and the three bolt heads in series).

23. If any tasks are not approved by the instructor, return to the applicable section of this workbook. Reaccomplish those particular steps.

24. If all tasks were approved by the instructor, remove all safetywire and the cotter pin from the safetywire trainer. Throw scraps in the trash can. Clean and put away your handtools. Tell the instructor that you are ready for the next task.

Technical Training

Aircraft Environmental System Mechanic

GENERAL PURPOSE CONNECTORS, BONDING,
SHIELDING, AND GROUNDING

11 August 1977

3350 TECHNICAL TRAINING WING
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NO USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42331, Instructional System. The material contained herein has been validated using students enrolled in the 3ABR42331 course. Ninety percent of the students taking this text have achieved or surpassed the criteria called for in the lesson objective. The average student required 21 minutes to complete this text.

OBJECTIVES

Identify the use of general purpose connectors, bonding, shielding, and grounding. A minimum of 70% accuracy must be obtained.

INSTRUCTIONS

This programmed text presents information in small steps called "Frames". After each frame you are asked to respond to the information in some way. Read the material and make your response. Compare your answers with the correct answers given at the top of the next page. If you find you are incorrect, reread the frame to get the correct information. If you are right, and you understand the information presented in that frame, proceed to the next. This is satisfactory, however, do not skip ahead unless the text directs you to do so.

OPR: 3370TTG

DISTRIBUTION: X

3370TTGTC - 600; TTVSR - 1

215

Aircraft electrical wiring is constructed of tin-coated copper or aluminum wire. Normally it is insulated, shielded, bonded and grounded (if needed) to the aircraft when installed. During inspection or repairs, make sure that insulation and shielding are not damaged.

Answer the following question by circling the correct answer.

1. Before installing an electrical wire from a shutoff valve to a circuit breaker, what would have to be done to the wire?
 - a. Insulated
 - b. Shielded
 - c. Bonded
 - d. Grounded (if needed)
 - e. All of the above

Answer to Frame 1: 1. a

Frame 2

Shielded cable must be properly bonded and secured. In each cable, many small strands of wire are used to form a single conductor. These stranded cables are preferred rather than a single heavy wire in order to make the finished cable more flexible. The individual strands are twisted together and then covered with a suitable insulating material. Where excessive vibration takes place, flexible stranded cable can cause trouble when not properly secured.

Answer the following question by circling the correct answer.

1. Given a choice between a stranded cable and a single heavy wire, why do maintenance people choose the stranded cable?
- a. Stronger
 - b. Lighter
 - c. Smaller
 - d. More flexible

Answer to Frame 2: 1. d

Frame 3

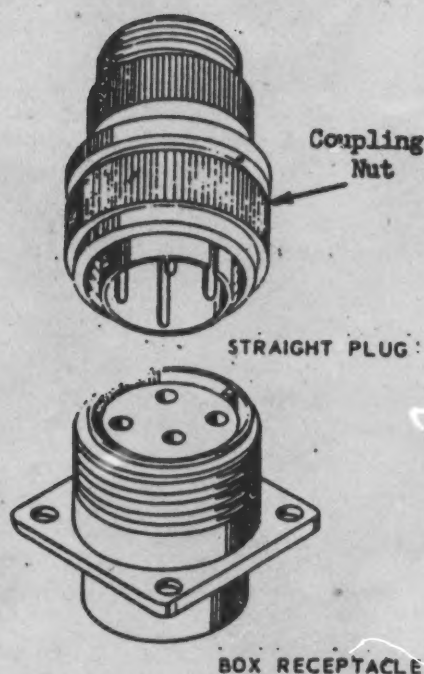


Figure 1. Common Connector.

Detachable connectors (cannon plugs) are used to join segments of electrical circuits installed in aircraft. These connectors must hold electrical circuits securely without undue voltage drop, under extreme vibration, rapid temperature changes, and vast altitude differences. A common connector consists of a plug assembly (see figure 1 for example) and a receptacle assembly that are fastened together by a coupling nut. You must be careful not to cross-thread, strip, or jam the nut.

Answer the following question by circling the correct answer.

1. What is the purpose of a cannon plug?
 - a. Connect insulation
 - b. Ground electrical circuits
 - c. Join segments of electrical circuits
 - d. Bond electrical circuits to aircraft structure

Answer to Frame 3: 1. c

Frame 4

We have covered some points in this book that are important for you to remember. Therefore, we will quickly cover them again.

- . Normally, aircraft wiring is insulated, shielded, bonded and grounded (if needed) to the aircraft when installed.
- . Stranded cables are preferred rather than a single heavy wire in order to make the finished cable more flexible.
- . Detachable connectors are used to join segments of electrical circuits installed in aircraft.
- . You must be careful not to cross-thread, strip, or jam the coupling nut on a connector plug.

Frame 5

Shielding - Preventing one component from affecting another through their common electric or magnetic field.



Figure 2. Shielded Multiconductor Cable.

Shielded cable (figure 2) has a metallic braid over the insulation to provide a barrier against electrostatic interference. To obtain satisfactory results from shielded cable, the shield must be unbroken and must extend to a point as near the end of the conductor as practicable.

Answer the following question by circling the correct answer.

1. What does a shielded cable (located inside a pressure regulator) protect against?
 - a. Heat
 - b. Water
 - c. Shorting
 - d. Electrostatic interference

Answer to Frame 5: 1. d

Frame 6

Grounding - The electrical connecting of wiring to a primary structure (the main frame, fuselage, and wing structure of the aircraft) for the return of current.

In the wiring of practical circuits, one side of the voltage source is usually grounded. For the 120VAC power line in residential wiring, the ground is actually earth ground, usually made by connecting a wire to a metal coldwater pipe. For aircraft equipment, the ground is connected to a metal chassis (see figure 3), which is used as a common return for connections to the voltage source.

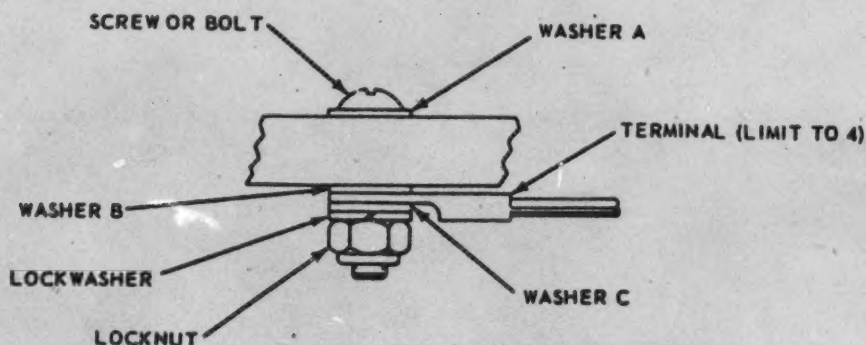


Figure 3. Grounding to Flat Surface.

Answer the following question by circling the correct answer.

1. If you need to check a component for 28VDC power, where would you ground the negative lead of thy multimeter?
 - a. Earth
 - b. Aircraft structure
 - c. Metal cold water pipe
 - d. To the control switch

Answer to Frame 6: 1. b

Frame 7

Bonding - The electrical connecting of two or more wires not otherwise adequately connected.

Bonding is used to connect wires (usually in bundles) to the aircraft structure for purposes other than grounding. The wiring used on aircraft can be many feet long. Therefore, it must be bonded in several places to prevent the wiring from breaking due to excess vibration. Bonding also keeps wiring from getting in the way of other equipment.

Answer the following question by circling the correct answer.

1. Why would your shop supervisor insist that you bond all the wiring bundles that you work on?
 - a. Helps insulation
 - b. Stops magnetic fields
 - c. Protects pilot from electric shock
 - d. Prevents wiring from breaking due to vibration

Answer to Frame 7: 1. d

Frame 8

In this book we have covered several items that are important for you to remember. Therefore, we will review them briefly.

1. Shielded cable provides a barrier against electrostatic interference.
2. Aircraft wiring is grounded to the aircraft structure.
3. Long wire bundles must be bonded to prevent the wiring from breaking due to excess vibration.
4. Detachable connectors are used to join segments of electrical circuits without undue voltage drops. The most common type of such a connector is called a cannon plug.

Frame 9

Wiring maintenance is an important part of environmental systems. In some cases one wire can prevent an aircraft from flying. That is why it is important for you to retain your basic wiring maintenance knowledge.



Technical Training

Aircraft Environmental System Mechanic

WIRING MAINTENANCE

20 January 1976



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

2066

Environmental Pseudraulic Branch
Chanute AFB, Illinois

3ABR42231-WB-303B

WIRING MAINTENANCE

OBJECTIVES

Given a workbook, tools and equipment, solder electrical wiring to connectors and install electrical wiring connectors to the specifications of TO 1-1A-14.

INSTRUCTIONS

Tell the instructor that you are ready to view the two films titled, "Stripping and Crimping" and "Wire Maintenance." After viewing the films, start with the instructions in this workbook.

EQUIPMENT

	Basis of Issue
5/16 Nut Driver	1/student
Terminal Lugs	4/student
Wire Splice Connections	4/student
Crimping Tool	1/student
Size 20 Wire	1/2" (30.5cm)/student
Wire Stripper	1/student
Diagonal Cutting Pliers	1/student
TO 1-1A-14	1/student
Soldering Iron	1/student
Soldering Iron Stand	1/student
Rosin Core Solder	1 roll/student
Flux	1 can/2 students
Wire Maintenance Trainer	1/student
Double-Cut Mill File	1/student

Note: Get the equipment at this time.

PROCEDURE

Note: Read the item through, completely, before performing each step.

1. Stripping Electrical Wiring

a. Before an electrical wire can be soldered it must have some of the insulation removed. Removing part of the insulation from the wire is called stripping.

b. Stripping electrical wires is done with a wire stripper. The type of stripper that you will use is a plier-type hand stripper.

Supersedes 3ABR42231-WB-303B, 8 October 1975, which may be used until existing stocks are exhausted.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 1

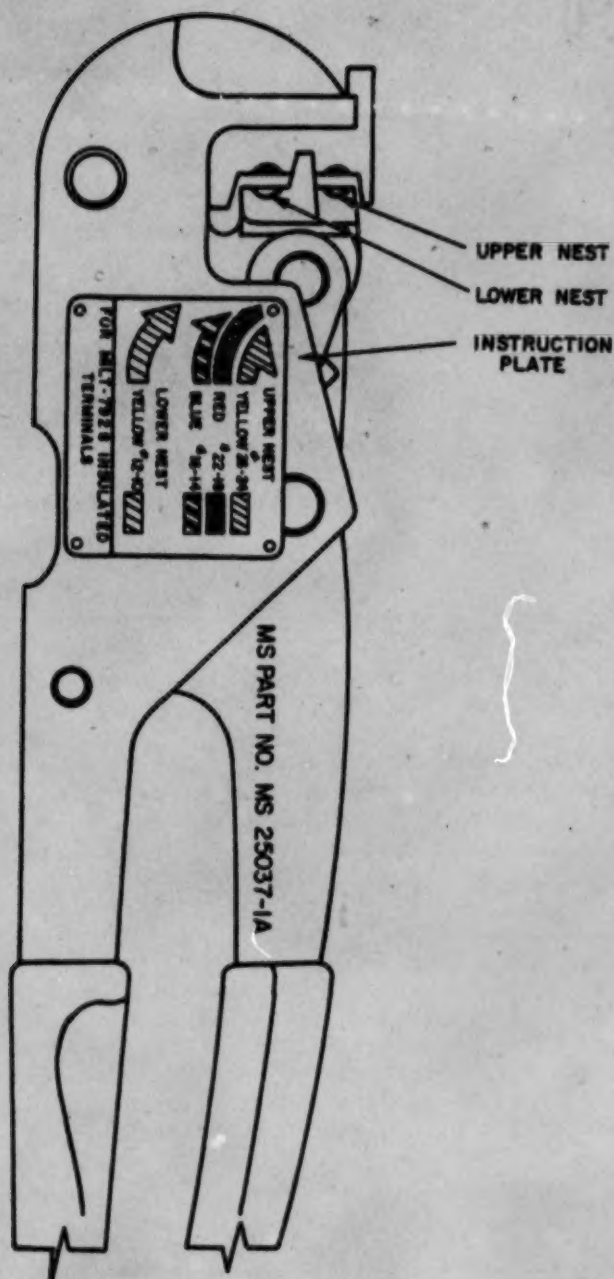


Figure 1. Crimping Tool.

c. In TO 1-1A-14, read paragraph 2-44. This paragraph gives the steps for stripping electrical wires. As you read this paragraph look at figure 2-21 in the TO.

d. Follow the steps in TO 1-1A-14 to strip each end of a 6-inch (15cm) piece of wire 3/16 of an inch (.476cm). When you feel that the wire is stripped, as shown in the TO, have the instructor check your work.

2. Application and Use of the Crimping Tool and Wiring Connectors.

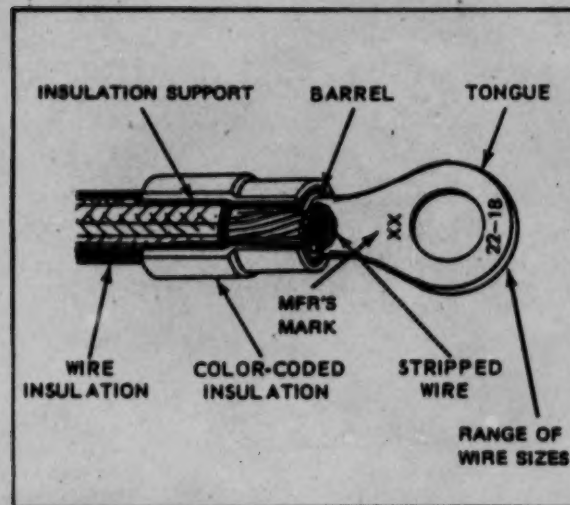


Figure 2. Preinsulated Terminal Lug - Cut-Away.

a. The crimping tool (figure 1), is used for connecting (crimping) preinsulated terminals (terminals with plastic covered barrels, figure 2) and splicing connectors to electrical wiring.

Answer the statements as true (T) or false (F).

1. ☐ Preinsulated terminals can be crimped with any type of crimping tool.

b. Insulated terminals and connectors are color coded for the size of electrical wiring with which they are to be used. The color coding is done by making the insulation of each size of terminal or connector a different color. The instruction plate on the crimping tool (figure 1) shows the nest (jaw section) that is to be used for the size of the wire and color of the terminal or connector.

Answer the statements as true (T) or false (F).

1. ☐ The instruction plate of the crimping tool shows the jaw section to be used by code.
2. ☐ Color coded connectors show the wire size that may be used.

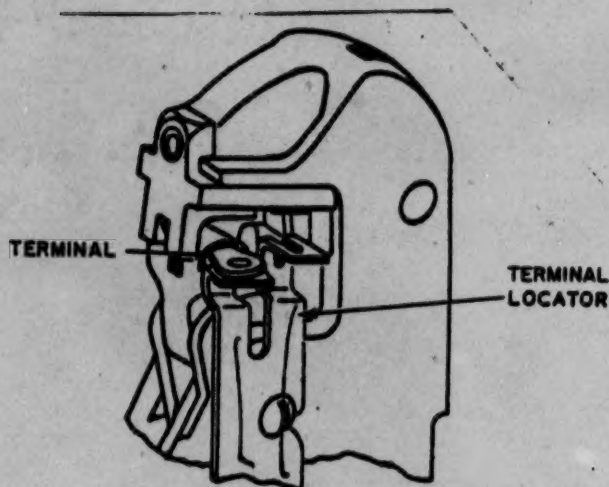


Figure 3.

c. Figure 3 shows the side of the crimping tool opposite the instruction plate side. On this side of the crimping tool is a terminal locator. This locator is used only when crimping a terminal lug. The locator acts as a stop for the lug. The locator can be turned out of the way. This is done when wire splice connections need to be crimped. The terminal is moved in the correct nest until the terminal barrel is against the locator (figure 3).

Answer the statements as true (T) or false (F).

1. ___ The locator on the crimping tool is used when crimping terminal lugs.
2. ___ The locator is on the same side of the crimping tool as the instruction plate.

d. This crimping tool has self-locking steps (ratchets). Once you start to close the handles, they will have to be closed all the way before the crimping tool will open again. The purpose of the self-locking ratchet is to give a means for locking connectors in the crimper. The wire can then be put in the barrel of the terminal lug or splice connection.

Answer the statements as true (T) or false (F).

1. ____ The crimping tool has a self-locking ratchet.
2. ____ The crimping tool may be opened no matter how far the handles have been closed.

Note: Another type of crimper has only one nest. The one nest can take all sizes of wire from number 10 through number 26. This type of crimping tool has a wire size selector knob. Other than this the two tools work the same.

e. Get a crimping tool. Operate it a few times without any connectors. Squeeze the handles slowly. Listen for a click at each step of the self-locking ratchet. Also, notice that the opening at the jaws gets smaller at each step of the self-locking ratchet.

3. Crimping Terminal Lug Connections

- a. Open TO 1-14-14 to page 5-9, read paragraph 5-14.
- b. Take a piece of wire 6 inches (15cm) long and strip one end so that 3/16 of an inch (.476cm) of the wire is showing.
- c. Twist the strands of wire so they can be put in the terminal lug barrel.
- d. Select a terminal lug. Put it, TONGUE first in the proper nest of the crimping tool. This is shown by the color code on the tool data plate. The barrel of the terminal lug should be up against the locator stop of the crimping tool (figure 3).
- e. Slowly squeeze the crimping tool handles until the terminal lug is held in place.

Caution: Do not squeeze so hard as to dent the terminal lug barrel.

f. Put the stripped end of the wire in the terminal lug barrel. Make sure the insulation of the wire is flush against the barrel of the terminal lug (figure 4).

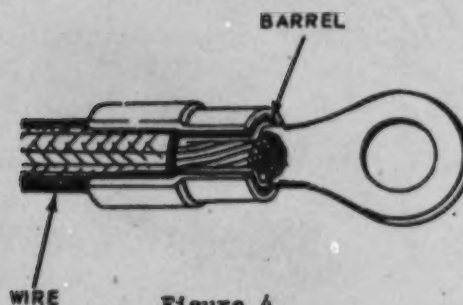


Figure 4.

- g. Squeeze the crimping tool handles closed. When the handles are closed, the ratchet will release.
 - h. Take the crimped terminal lug from the crimping tool.
 - i. Have the instructor check your work.
4. Crimping Wire Splice Connections
- a. Turn to page 5-30 in TO 1-1A-14 and read paragraph 5-53.
 - b. Take the wire that you just crimped a lug to, and cut it in half, strip one end of each wire about $\frac{3}{16}$ of an inch (.476cm).
 - c. Twist the strands of wire so they can be put in the barrels of the splice connection.
 - d. Turn the locator stop down and out of the way (figure 5).

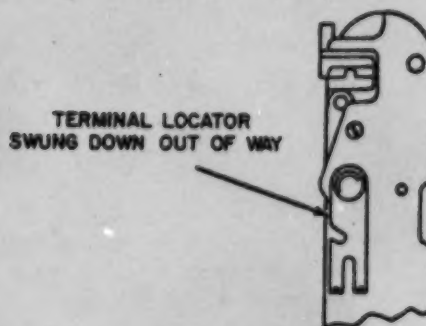


Figure 5.

- e. Select a splice connection. Put it in the crimping tool, so that the collar of the splice connection is in the locator groove (figure 6). Be sure that the side of the splice to be crimped is on the conical die side of the locator groove in the upper nest.

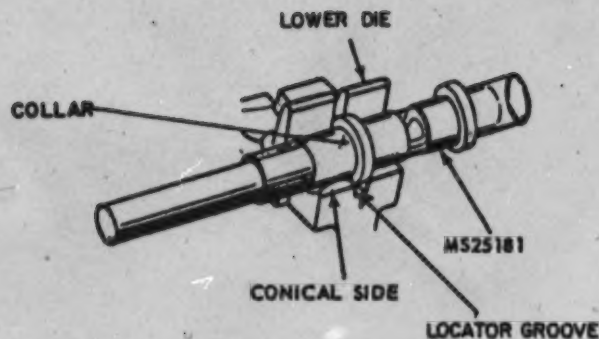


Figure 6.

f. Put the wire in the wire inside of the splice connector until it stops.

Caution: Do not get fingers or any objects caught in the jaws of the crimping tool.

g. Crimp the connection by squeezing the handles of the crimping tool all the way closed.

h. Take the wire splice connection from the crimping tool. Check to make sure the connection is tight.

i. Have the instructor check your work.

j. Take the splice that you just made and turn it around and install it in the crimping tool.

k. Take the other half of the wire with the terminal lug on it and put it in the splice and crimp it down. Have the instructor check your work.

5. Soldering Electrical Connections

a. To know how to make good electrical connections with solder is important, because of the many different conditions to which an aircraft is subjected. The electrical connections must be able to carry electrical current with no loss of current due to leakage or resistance.

b. A detachable electrical AN-connector (figure 7) has a plug (male) and receptacle (female) assembly. The two parts are fastened together by means of a coupling nut. You must take care not to crossthread, strip, or jam the nut. Notice also, that the pin contacts in the AN-connector have cups in which a wire can be placed and soldered.

c. In TO 1-1A-14, Section IX, read paragraph 9-7 that defines soldering.

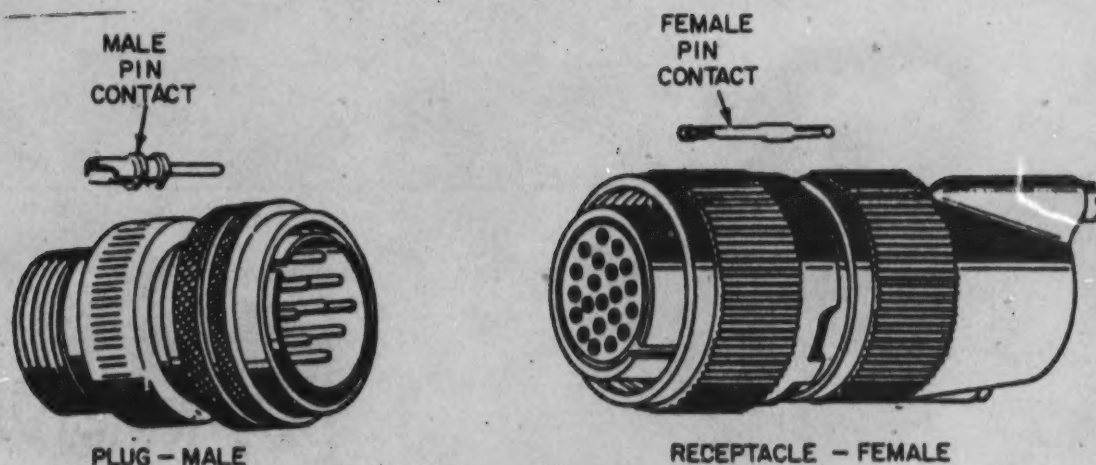


Figure 7. AN-Connector.

d. Solder used for soldering electrical wiring is usually of the 40-60 type. This means that the solder has 40% lead and 60% tin. Solder may be of the core wire or solid wire type. Core wire solder has a core of flux, that may be rosin or acid. Rosin core solder is always used when soldering electrical connections.

Note: Never use acid core solder, for electrical connections. Acid core solder tends to cause corrosion and this will cause a high resistance to the flow of electrical current.

Solid wire solder may be used for soldering electrical connections. When this type of solder is used the rosin flux will have to be put on the wire.

e. Flux is a chemical reducer that is used for conditioning the surfaces to be soldered. When the surface is heated to melt the solder, the flux will melt before the solder. This will help the solder remove any chemical substance that may cause the solder not to stick to the metal. The rosin flux will also help stop oxidation when the metal is heated.

f. Soldering irons are rated by wattage. The irons can be had in wattages that range from 20 to 500 watts. Soldering irons with wattage ratings of 60, 100, and 200 watts are for general use in soldering electrical wiring.

6. Procedure for Soldering Electrical Connections

a. Tell the instructor that you are ready to use the wire maintenance trainer (figure 8).

b. Make sure the trainer is UNPLUGGED and the circuit breaker is pulled OUT.

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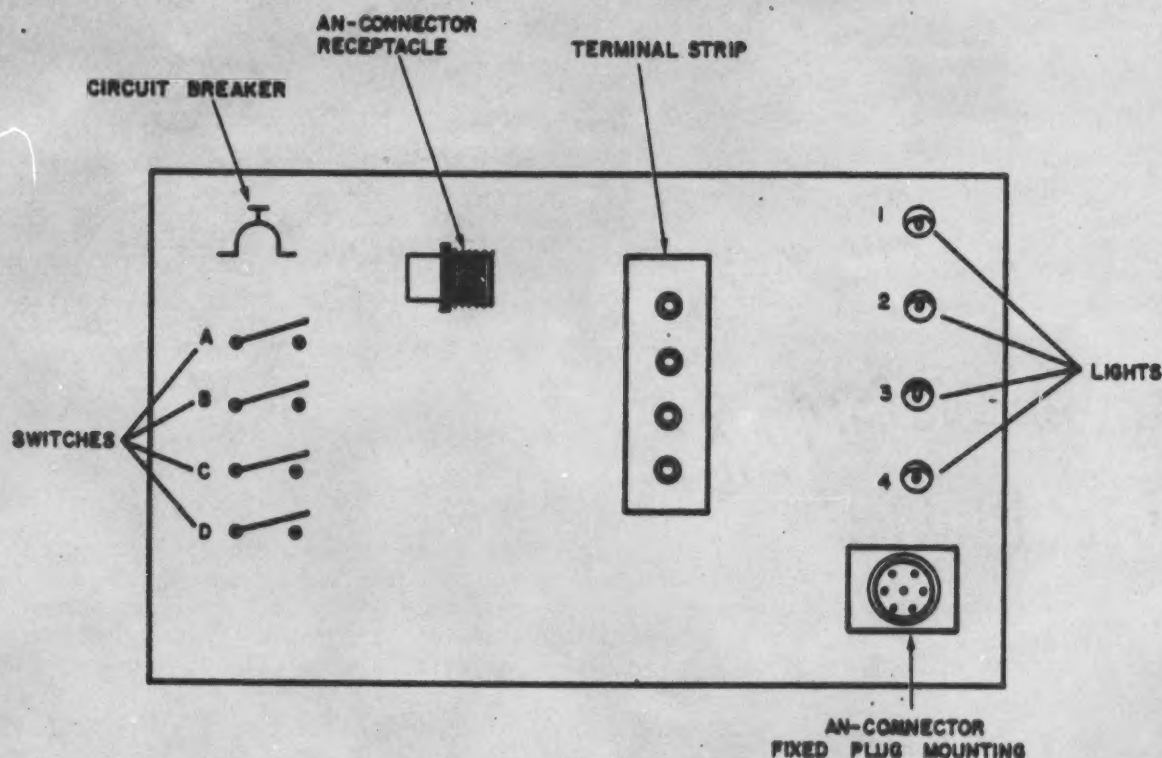


Figure 8. Wire Maintenance Trainer.

c. Just below the circuit breaker there are four single pole switches, marked A, B, C and D. Make sure each switch is OPEN.

d. To the right of the switches is an AN-connector. Remove the plug from the AN-connector. Put the plug on the fixed plug mounting.

e. Refer to figure 9 and remove the grommet and back nut from the plug of the AN-connector.

f. Cut a piece of wire 6-inches long (15cm). You will use the wire that you spliced in the previous steps for the second wire.

g. Refer to Section 1 of this workbook and strip one end of each wire one-fourth of an inch (0.635cm).

h. Turn to Section II of TO 1-1A-14 and read paragraphs 2-48 through 2-50.

i. Tin the soldering iron by following the steps in TO 1-1A-14, Section IX, paragraph 9-20.

j. Tin the stripped end of each wire by following the steps in TO 1-1A-14, Section II, paragraph 2-54.

Note: If you need help ask the instructor.

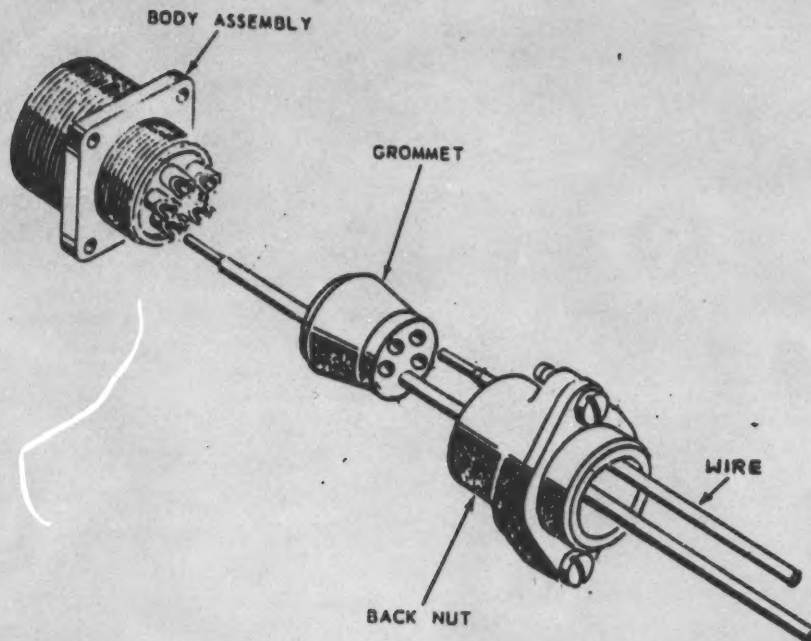


Figure 9.

k. Refer to figure 9 above. Slide the back nut about half way up the wires putting the tinned ends through first. Now push the tinned ends of the wires through the grommet so that the wires will line up with the pins. Push the grommet up the wires to the point where the one wire is spliced.

1. Turn to Section IX of TO 1-1A-14 and read paragraphs 9-32 through 9-40.

m. Solder the tinned ends of the wires to the pins of the AN-connector. Follow the steps in paragraphs 9-32 through 9-40 in TO 1-1A-14.

Note: Have the instructor check your work.

n. Disconnect the wires from the AN-connector. You are going to solder the wires into the AN-connector so that switch

_____ will turn on light _____ and switch _____ will turn on light _____. Follow the steps of paragraphs 9-32 through 9-40 in TO 1-1A-14.

o. After the wires have been soldered to the AN-connector, reassemble the plug (see figure 9). Push the grommet down the wires to the body assembly. Push the back nut over the grommet and screw it onto the body assembly. Now remove it from the fixed plug mounting and connect it to the receptacle (see figure 8).

p. Refer to Section 1 of this workbook and strip the wire end that has no terminal lug. Now refer to Section 3 of this workbook and crimp a terminal lug to this wire. Take the nuts off of terminals ____ and ____ with the 5/16 nut driver.

q. Connect the wire from pin ____ of the AN-connector to terminal ____ on the terminal strip. Connect the wire from pin ____ of the AN-connector to terminal ____ on the terminal strip. Tighten the nuts on the terminals so that they are snug.

Note: Have the instructor check your work.

r. Plug the trainer into the 28V DC outlet and push the trainer circuit breaker in.

s. Close the contacts of switch ____, light ____ should illuminate. Close the contacts of switch ____ and light ____ should come on. If the lights do not illuminate, ask the instructor for assistance.

t. Open the contacts of the switches you closed, pull out the trainer circuit breaker and unplug the trainer.

u. Remove the two wires from terminal strip.

v. Take the AN-connector off the AN-receptacle and put it on the fixed mounting (see figure 8). Disassemble the AN-connector and unsolder the wires. Remove the wires from the back nut and grommet and reassemble the AN-connector.

w. Inform the instructor you have completed this project.

The instructor will give you further instructions.

2077

Environmental Pneudraulic Branch
Chanute AFB, Illinois

3ABR42331 -WB-303C
8 October 1975

AIRCRAFT HANDTOOLS

OBJECTIVES

Given this workbook and the use of equipment lockers #3 and #4 and applicable handtools, select and identify the handtools used for the tasks listed, with not less than 70% accuracy.

EQUIPMENT

Equipment Locker #3
Equipment Locker #4
Applicable Handtools

Basis of Issue
1/student
1/student
1 box/student

PROCEDURE

From equipment lockers #3 and #4, get the proper handtools for the tasks listed. Write the name of the handtool in the blank that corresponds with the task. When you have finished, take the handtools and this workbook to the instructor for verification and grading. When he signs your record, return all the tools to the proper place.

<u>Task</u>	<u>Handtool</u>
1. Used to break loose stubborn nuts.	_____
2. Used on Phillips type screws.	_____
3. Used on odd sized nuts.	_____
4. Type of pliers used for cutting.	_____
5. Used for beating on soft materials.	_____
6. Used for cutting hard materials.	_____
7. Measures twisting force on nut or bolt.	_____
8. Used to remove common screws.	_____
9. Used to twist safety wire.	_____
10. Used when a boxend wrench won't work.	_____

OPR: TAS

DISTRIBUTION: X

TAS - 500; TTVGC - 2

Designed for ATC Course Use. Do Not Use on the Job.

Environmental Pseudraulic Branch
Chenute AFB, Illinois

3ABR42331 -WB-303D
16 October 1975

AIRCRAFT HARDWARE

OBJECTIVES

Given a workbook and three aircraft hardware display boxes, match selected items with a list of uses, with not less than 70% accuracy.

EQUIPMENT

	Basis of Issue
Aircraft Hardware Display Boxes	3/1 student

PROCEDURE

Go to the three aircraft hardware display boxes that are on the front wall of classroom A-115. Read each of the statements below. Match the statements to the corresponding items of hardware. The items may be in any of the three display boxes. There may be more than one answer for each statement.

The three display boxes are labeled A, B, and C. Put the number of the hardware item in the blank space to the right of each statement, under the corresponding display box letter.

Display Box Letters

A B C

1. The item that would be used to safety a castellated nut is number

2. The nut that can be tightened with the fingers and used on a part that is removed frequently is number

3. The type of bolt used in bolting the wing to the fuselage of an aircraft is number

4. The type of screw used to attach nameplates to castings is number

5. The bolt that is made of steel and used where shear strength is needed is number

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 2

Designed for ATC Course Use. Do Not Use on the Job.

Display Box Letters

A B C

6. The type of nut that is used for blind mounting and easier maintenance is number

7. The type of bolt that is used where fatigue resistance and tensile strength are needed is number

8. The item that would be used to connect a pipe thread tube to a flared tube is number

9. Three flared tubes have to be connected together, one is at a right angle to the other two. The item that would be used is number

10. The fitting that would be used to connect two flared tubes is number



Technical Training

Aircraft Environmental Systems Mechanic

OPERATION OF AN AIRCRAFT AIR CONDITIONING
SYSTEM MOISTURE SEPARATOR

19 August 1975



CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR42231-PT-403, 20 July 1972.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 2

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the Aircraft Environmental Systems course. The average time required to complete this text was 20 minutes.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Recall the function of the moisture separator components.
2. Explain the principles of operation of the moisture separator assembly.
3. Name the main parts of a basic moisture separator with 80% accuracy.

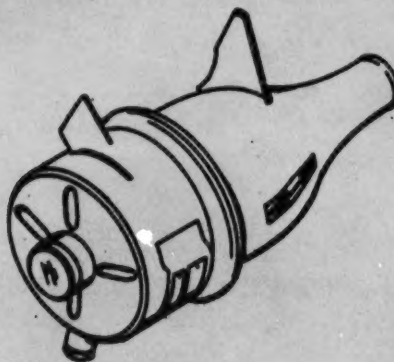
INSTRUCTIONS

This program presents information in small steps called "frames." After each step you are asked to select the correct statement, match some statement, or respond to the information presented in some other way. Read the material presented and make your response on the response sheet. DO NOT MARK IN THIS TEXT. Compare your responses with answers at the top of even numbered pages. If you are wrong, read the frame again.

Frame 1

An aircraft moisture (water) separator in an air conditioning system is made to remove 70 to 85% of the water from the air that is passed through it. The water is in the form of a vapor. The size and shape of the separator is determined by (1) the size of the cabin in the aircraft (2) the amount of air put out by the air conditioning system, and (3) the location of the separator in the system.

Let us consider the unit used by a typical cargo aircraft. This unit is about two feet long and 12 inches in diameter. This cone-shaped unit has an opening at both ends; one for air IN and one for air OUT. We are mostly interested in how it works inside. The complete unit is shown in the diagram.



Answer the statements as true (T) or false (F).

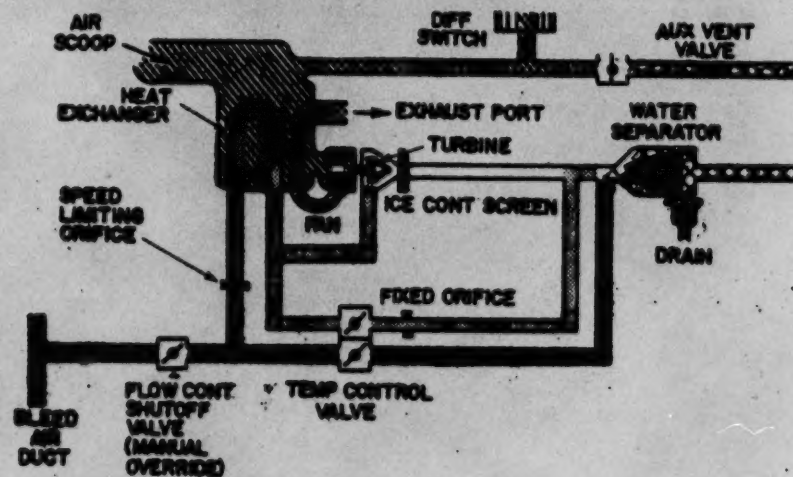
1. All water separators are the same size.
2. Size determines the basic operation of a moisture separator.
3. The moisture separator removes a large percentage of the water vapor from the conditioned air.

2083

Correct Responses to Frame 1: 1. F, 2. F, 3. T.

Frame 2

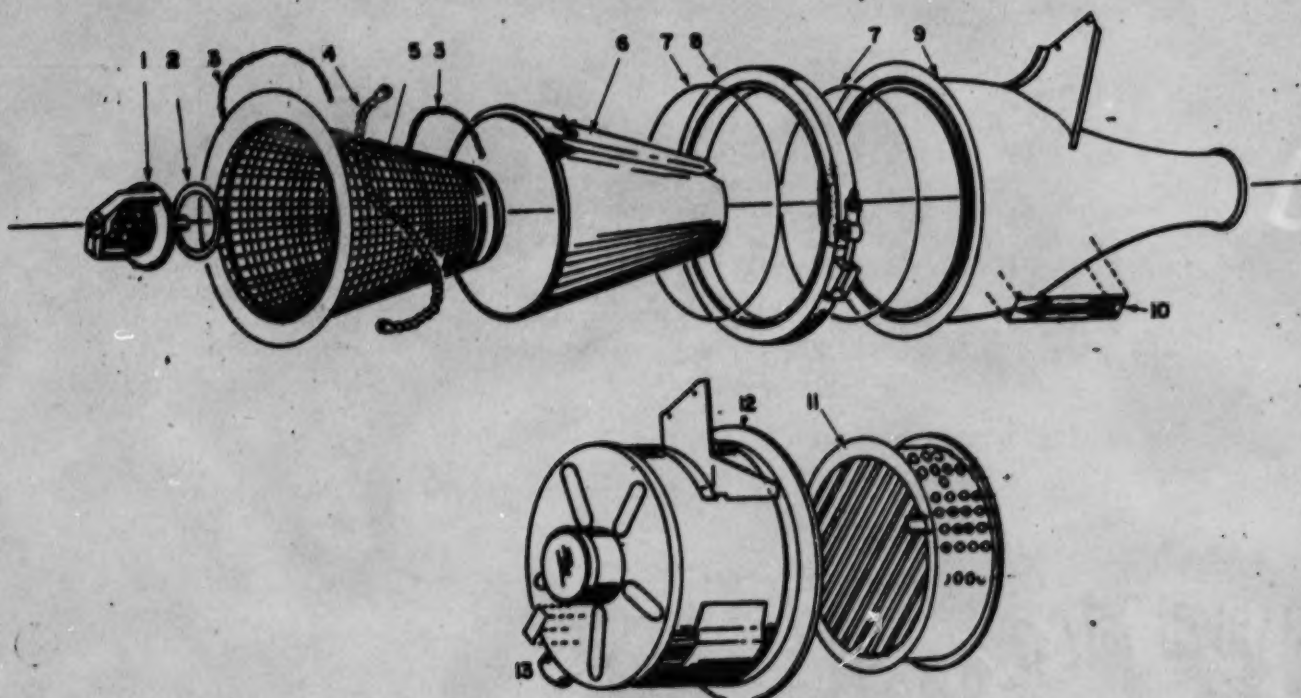
In the diagram, you can see the location of the moisture separator in the system. Note, all the conditioned air must pass through the separator. All aircraft have the separator located downstream of the refrigeration unit. You will recall that cold air does not hold as much water as warm air. So, due to the fast cooling of the air through the turbine, the water vapor in the air will condense into a fog. This fog will form water droplets, and in some cases, snow or ice crystals. We do not want this fog, rain, snow or sleet to blow into the cabin. It is removed by the moisture separator.



Complete the statements.

1. Moisture separators are always _____ of the turbine.
2. _____ % of the conditioned air passes through the moisture separator.
3. _____ air holds more water than _____ air.

Identification of parts of a moisture separator.



- | | |
|----------------------------|---------------------------------|
| 1. Bypass valve | 8. V-band clamp |
| 2. Seal | 9. Shell assembly (inlet end) |
| 3. Springs (2) | 10. Arrow |
| 4. Chain | 11. Eliminator assembly |
| 5. Support | 12. Shell assembly (outlet end) |
| 6. Conical condenser | 13. Drain |
| 7. Rubber O-ring seals (2) | |

Study the illustration until you are able to identify each part from memory.

NO RESPONSE REQUIRED

Correct Responses to Frame 2: 1. downstream, 2. 100, 3. warm/cold.

Correct Response to Frame 3: None Required.

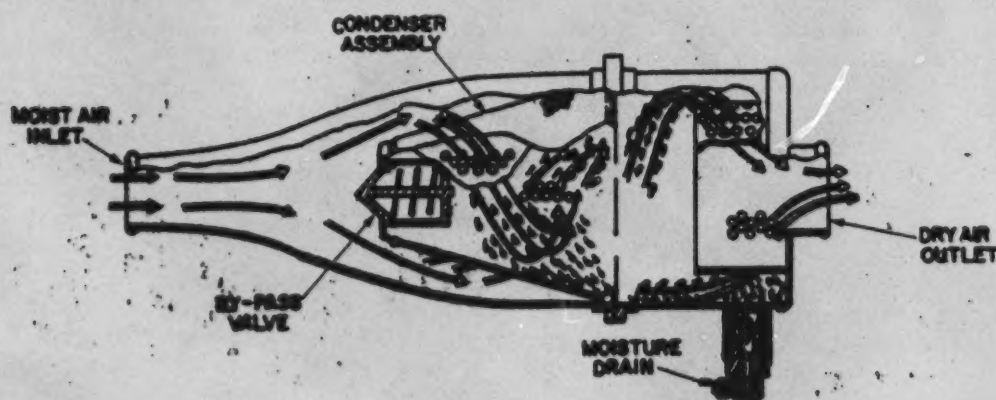
Frame 4

Grooved flanges are welded to both parts of the shell assembly, where the two shell halves join. O-ring seals are installed in these grooves to stop air and water leakage during operation. The air inlet and outlet connections (see illustration in frame 3) are beaded and fastened to the rest of the air conditioning ducting by rubber sleeves. The sleeves are held in place by clamps. Welded on the side of the shell assembly are brackets that allow the entire assembly to be bolted to the aircraft. An arrow on the shell shows which way the air flows. Aligning pins on the flanges are used to properly fit the two halves of the shell assembly together.

Complete the statements.

1. The O-ring _____ prevents air and water leakage at the clamp connection.
2. The arrow on the shell assembly indicates _____ of _____.
3. The moisture separator is bolted to the _____.
4. The inlet and outlet connections are beaded and fastened to the air conditioning ducting by rubber _____.

The conical condenser fits snugly over the support. It is held in place by a spring at the small end and a spring and chain assembly at the large end. As the cold air comes off the turbine, the water vapor condenses into a fog made up of small water droplets. The condenser will cause these small droplets to condense into large droplets (fuse together).



The air goes through the condenser and hits the support. The support is louvered and will give the air a swirling motion as it goes through. This swirling will cause the water droplets to be thrown outward and against others, forming still larger drops. This water and air mixture then goes through the eliminator assembly. The drops of water strike and run down the vertical rods of the eliminator to the bottom of the shell assembly. The water collects here and is drained overboard.

Complete the statements.

1. The conical condenser fits _____ over the support.
2. The conical condenser _____ the water droplets _____.
3. The conical condenser gathers _____ water droplets into _____ water droplets.
4. The conical condenser fits over the _____.
5. The louvered support gives the air a _____ motion.
6. The _____ assembly takes the water out of the air.

Correct Responses to Frame 4: 1. seal, 2. direction/air flow,
3. aircraft, 4. sleeves.

Correct Responses to Frame 5: 1. snugly, 2. fuse/together,
3. tiny/larger, 4. support, 5. swirling, 6. eliminator

Frame 6

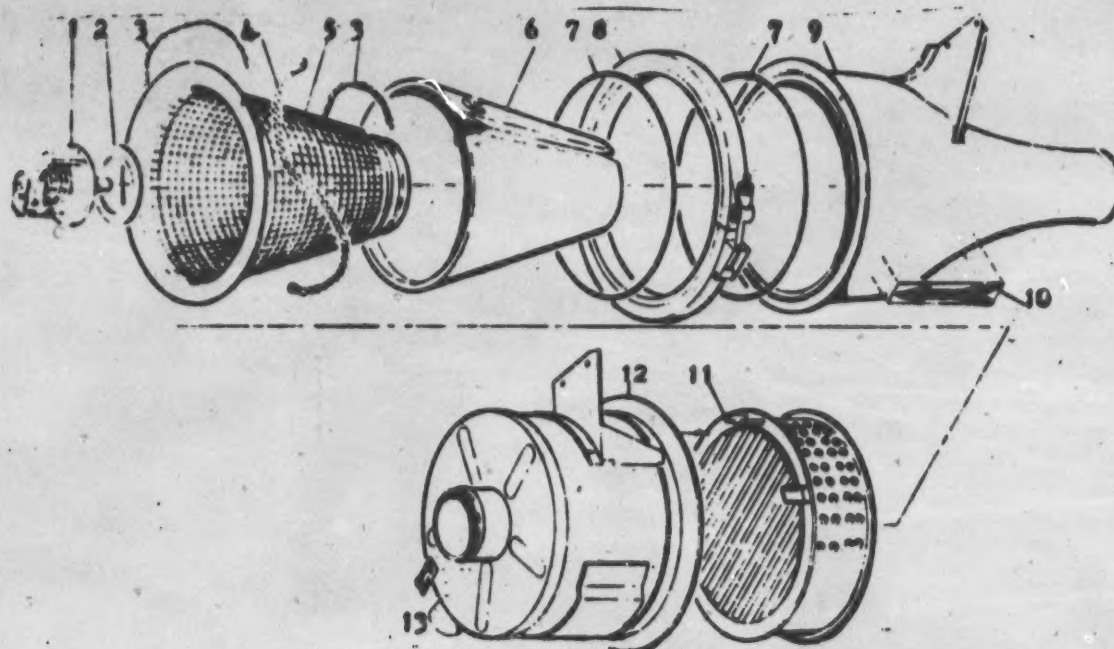
A bypass valve is in the small end of the support (see the illustration in frame 5). This is the end of the support that first receives the flow of air. This air, as you will recall, comes from the turbine and is quite cold. The temperature of the air might even drop below the freezing point. If this occurs, the water condensed by the conical condensor might turn into a solid sheet of ice. The ice would cause the flow of air to stop. This is where the bypass valve comes in. Since we MUST have a flow of air to the cabin, this safety device was built in. The bypass valve works like a pressure relief valve. The bypass valve is held closed by a spring. In this closed position the valve will force all of the air to flow through the conical condensor. The air can then rid itself of moisture. If the conical condensor freezes over pressure will build up, upstream of the bypass valve. When the air pressure is more than the pressure of the bypass valve spring, the bypass valve opens and lets the air pass through. But, this time the air carries with it any moisture that is generated from the refrigeration process. Keep in mind, the flow of air to the cabin is a MUST, whether or not it carries moisture.

Complete the statements.

1. The bypass valve is installed in the _____ end of the support.
2. The bypass valve is held closed by a _____.
3. Air flow to the cabin is a _____.

Frame 7

Identify each part of the moisture separator. If in doubt, go back to Frame 3 and review.



- | | |
|----------|-----------|
| 1. _____ | 8. _____ |
| 2. _____ | 9. _____ |
| 3. _____ | 10. _____ |
| 4. _____ | 11. _____ |
| 5. _____ | 12. _____ |
| 6. _____ | 13. _____ |
| 7. _____ | |

Conical condenser
Support
V-band clamp
Drain
Chain
Springs (2)
Shell assembly (inlet)

Rubber O-ring seals
Eliminator assembly
Seal
Shell assembly (outlet)
Bypass valve
Arrow

Check your responses for Frames 6 and 7 on page 8. If you missed any of the questions in Frame 7, check yourself by rereading the frame containing the information asked by the matching items. If you need help, ask your instructor.

2089

Correct Responses to Frame 6: 1. small, 2. spring, 3. MUST.

Correct Responses to Frame 7:

- | | |
|-----------------------------|--------------------------|
| 1. Bypass valve | 8. V-band clamps |
| 2. Seal | 9. Housing (inlet end) |
| 3. Springs (2) | 10. Arrow |
| 4. Chain | 11. Eliminator assembly |
| 5. Support | 12. Housing (outlet end) |
| 6. Conical condenser (sock) | 13. Drain |
| 7. Rubber O-ring seals (2) | |

**Technical Training****Aircraft Environmental System****MAINTENANCE OF MOISTURE SEPARATORS**

16 October 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

2091

Environmental Pseudraulics Branch
Chanute AFB, Illinois

3ABR42231-WB-304

MAINTENANCE OF MOISTURE SEPARATORS

OBJECTIVES

After completing this workbook, you will be able to:

1. Remove and replace the condenser bag and bypass valve from the moisture separator.
2. Inspect the condition of a moisture separator by following technical order instructions.

Standard of performance:

Each student will be evaluated by an instructor using a checklist.

EQUIPMENT

	Basis of Issue
TO 15A7-2-11-13	1/2 students
Moisture Separator Assembly	1/student
Ratchet Handle, 3/8" Drive	1/2 students
Socket, 3/8" X 3/8" Drive	1/2 students
Duckbill Pliers	1/2 students
Side-cutter Pliers (Dikes)	1/2 students
Four (4") Common Screwdriver	1/2 students
Safety Wire, .032 Size, Steel	1/2 students
Safety Goggles	1/student

INSTRUCTIONS

As this workbook progresses, you will be directed to locate certain items, follow directions, or do certain tasks. At all times there will be an instructor available to help you. Be sure to ask him any questions you might have about the process of maintaining this item. Get the equipment you will need at this time.

INFORMATION

There are several reasons why you need to work on the moisture separator. During certain periodic and hourly inspections you will need to clean the conical condenser. While troubleshooting a maintenance write-up on the air conditioning system you may need to work on the moisture separator. The proper and timely maintenance of the moisture separator is one of your responsibilities.

Supersedes 3ABR42231-WB-403, 13 July 1972.

OPR: TAS

DISTRIBUTION: X

TAS - 500; TTVGC - 2

Designed for ATC Course Use. Do Not Use on the Job.

In this workbook, you will be taught how to maintain and inspect the moisture separator.

When you work with fiberglass, as is this condenser bag, you must wear protective clothes and rubber gloves. To make the job easier for you and to save the Air Force money, the fiberglass bag has been replaced with a plastic bag here at school. You will not need to wear protective clothes and gloves. Also, you will not wash the bags, as they do not get dirty here in school. If washed too much the bags would deteriorate fast.

PROCEDURE

1. All maintenance made on an aircraft, or a part from an aircraft must be done to technical order (TO) specifications. Open the TO to page 1.

a. Write the part number of each water separator that this TO will cover. _____

b. On the moisture separator you have, find the data plate and list the following:

(1) Stock number _____

(2) Part number _____

(3) Serial number _____

c. Does the part number of the moisture separator match one of the parts numbers listed on the front page of the TO?

(Yes) _____ (No) _____

Note: If the parts numbers do not match, you have the wrong TO. If the parts numbers do match, you have the correct TO. You may start with the tasks in the workbook. If the numbers did not match, tell the instructor.

From this point on, make sure you read and fully understand each step before you do the task. Watch how each part comes off, as you will need to assemble it by yourself. If you have questions, be sure to ask the instructor.

2. Use the IPB (figure 3) of the TO and the instructions given to disassemble the moisture separator assembly.

a. Start by removing the V-band clamp (12) that holds the two halves together.

b. Remove the spring (18) from the small end of the conical condenser support assembly (35).

2093

c. Remove the conical condenser from the support assembly and lay it on the bench in front of you.

Warning: Safety goggles must be worn when you work with safety wire.

d. Use the dikes to cut the safety wire from the six screws that hold the bypass valve (24) to the support. Remove the screws and the bypass valve.

Note: Do not try to disassemble the bypass valve.

e. It is now time to inspect each part. Use the information found in the inspection section (paragraph 4) of the TO to make a thorough inspection of each part. List all discrepancies below.

Inspection Findings

Drain (6 - 11) _____

Shell assembly (15 - 36) _____

Bypass valve (24) _____

Threaded parts _____

Nonkitted parts _____

Note: A kitted part is one that comes in an overhaul or repair kit. Nonkitted parts are large parts that must be ordered separately.

f. After you have made the inspection, tell the instructor.

3. Reassemble the moisture separator.

a. Install the bypass valve on the support assembly, then safety wire the screws. Have the instructor inspect your safety wire job before you go to the next step.

b. Slide the conical condenser over the support and install the spring on the small end.

c. Install the conical condenser support assembly back in the inlet shell assembly.

d. Use the alignment pin and hole to be sure the shell assemblies are aligned. Be sure the O-ring seals (13) are in the grooves.

e. Install the V-band clamp and tighten the nut with the ratchet wrench.

4. The first part of the project is done. Place all tools, equipment and the moisture separator in the proper storage area.

5. In part two of the project you will use an AFTO Form 349 to account for your time and the work you did.

a. Remove TO 1C-130A-06, Work Unit Code Manual from the TO training file. Ask the instructor for an AFTO Form 349.

b. Use TO 1C-130A-06 and the information listed below to fill out the AFTO Form 349.

Job Control Number - 2570521

Work Center - C3360

ID Number - CA4051

Priority - 2A

Location - Shop

Type Maintenance - Unscheduled

When Discovered - Minor Inspection

6. After you have finished, ask the instructor to check your work.



Technical Training

Aircraft Environmental Systems Mechanic

MAINTENANCE OF BLEED AIR DISTRIBUTION DUCTING

8 October 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42231 instructional system. The material contained herein has been validated using 30 42010 students enrolled in the 3ABR42231 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objectives. The average student required 15 minutes to complete the text. After completing this text you will be able to attain the objectives with an accuracy of 70%.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Identify factors that damage ducting.
2. State the reasons for insulation.
3. Describe the types of insulation repair.
4. Identify the types of damage to ducting.
5. Describe the corrosion prevention processes.

INSTRUCTIONS

This text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the true statement(s) from the list. The answers to the correct statements can be found on the top of the next page. DO NOT MARK IN THIS TEXT. If you select the correct answer continue to the next frame. If you chose the wrong answer, correct yourself before continuing.

As you read the text, ducting will be available in the classroom for your inspection.

Supersedes 3ABR42231-PT-404, 24 February 1970.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 2

Frame 1

Let us consider some of the things that damage bleed air ducting. Two of the main things are vibration and people. Vibration can be kept to a minimum by proper duct mounting. Most damage is caused by mechanics that walk on or hit the ducting with hammers, screwdrivers, etc. These careless actions dent and twist the ducting. The mechanics can also cause damage to the ducting by overtightening clamps, nuts, and bolts. If these clamps are too tight, a duct can be cracked. If the clamps are too loose, they may leak and, in time, will cause a hole to burn in the duct flange.

Answer each of the statements as true (T) or false (F).

1. Mechanics cause the most damage to a duct.
2. If the clamps are too tight, they can crack the duct.
3. Nothing happens if clamps are not torqued properly.
4. The mechanic should never step on ducting.
5. If the clamps are too loose, they could cause leaks.

2098

Answers to Frame 1: 1. T 2. T 3. F 4. T 5. T

Frame 2

Insulation around the ducting is used for several reasons. It prevents the mechanics from burning themselves, and protects wiring and equipment near the ducting from getting too hot and then burning. This insulation is fireproof, and the cover is watertight and airtight. It is made of fiberglass cloth.

The cover of the insulation is what you will be repairing in the field.

Answer each of the statements as true (T) or false (F).

1. Insulation is used to prevent burns.
2. The insulation is made of fiberglass cloth.
3. The insulation is not watertight.
4. The insulation is airtight.
5. The cover of the insulation is repaired in the field.

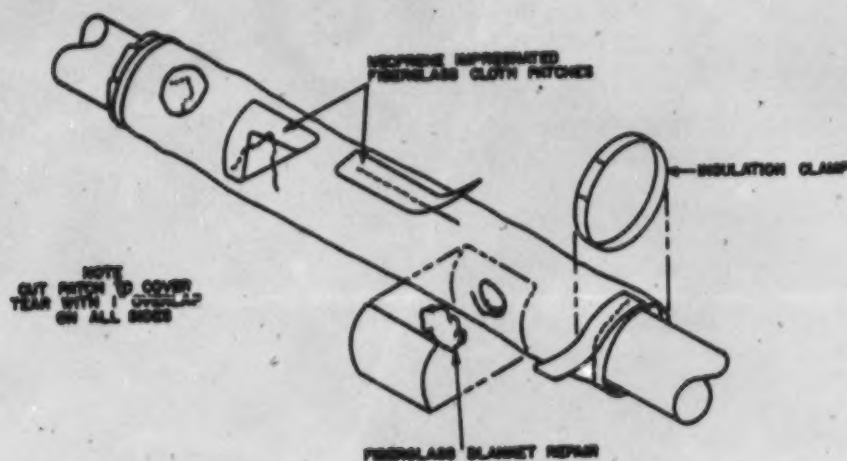
Answers to Frame 2: 1. T 2. T 3. F 4. T 5. T

Frame 3

The three (3) types of insulation repairs that can be made are cemented, sewed, and spot-welded.

Let us first talk of the cemented repairs. The same type of material that is patched is also the patching material.

As shown in the figure, be sure you cut the patch for cementing at least one inch larger on all sides. This allows the patch to hold in place when the cement (glue) is put on the patch.



Answer each of the statements as true (T) or false (F).

1. Cemented, sewed, and spot-welded are types of insulation repair.
2. Fiberglass cloth is used to repair fiberglass insulation.
3. The patch is smaller than the rip.
4. Cement (glue) is used to repair cemented type repairs.
5. The patch is larger than the rip.

Answers to Frame 3: 1. T 2. T 3. F 4. T 5. T

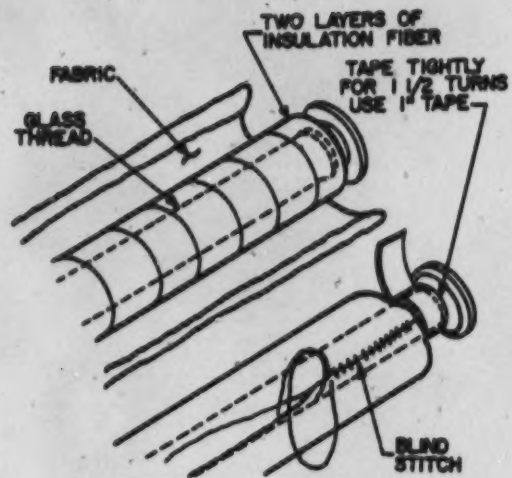
Frame 4

The sewed insulation is shown in the top figure. Fiberglass thread is used to fix this type of insulation rip. A curved needle is used to make a blind stitch.

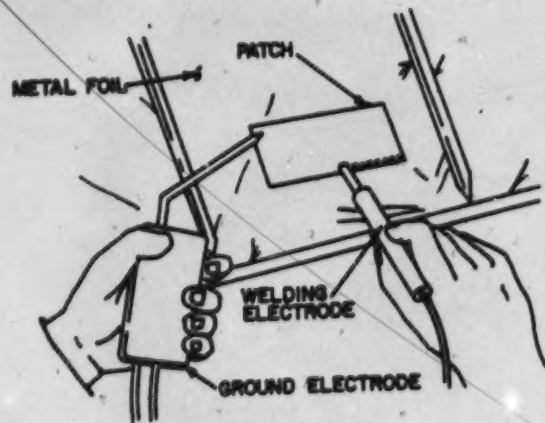
When metal foil insulation must be fixed, a spot welder is used as shown in the bottom figure. A metal foil patch is put directly on the metal foil insulation.

Answer each of the statements as true (T) or false (F).

1. Fiberglass thread and a curved needle are used to sew the insulation.
2. The ground electrode must make contact with the patch while the welding electrode is being used.
3. The metal foil patch must be larger than the rip.



Sewed Insulation Repairs



Repairing Metal Foil Insulation

Answers to Frame 4: 1. T 2. T 3. T

Frame 5

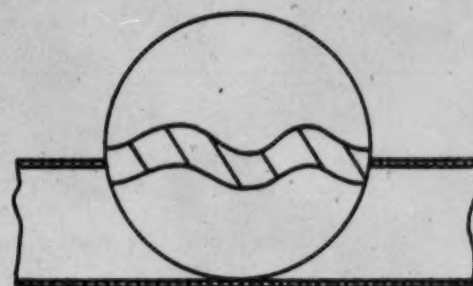
Wrinkles, dents, and scratches, shown in the figure, are the three types of damage that occur to ducting.

Wrinkles and dents will slow the flow of air and cause hot spots in the ducting. Wrinkles can not be less than 1/2" long when more than 1/8" deep. Dents can not be more than 1/16" deep when less than 5/8" long. These limits are set for if the dent or wrinkle were deep and too short, the sharp metal crease that goes in the airstream would disturb the flow of air beyond acceptable limits. A scratch can not be more than 2/1000" (.002") deep. If a scratch is too deep the scratch will weaken the duct wall and leakage can occur.

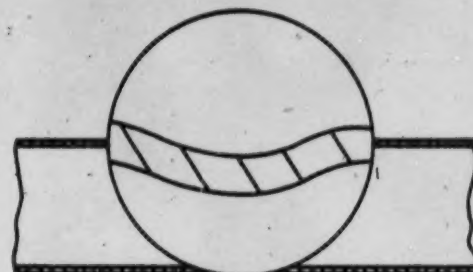
It is not necessary to remember the damage limits, but you should remember it does not take much damage before the duct must be replaced.

Answer each of the statements as true (T) or false (F).

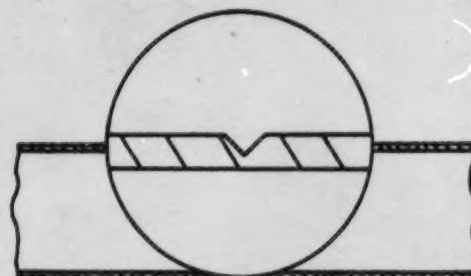
1. The three categories of damage are wrinkles, dents, and scratches.
2. Wrinkles slow the airflow and cause hot spots.
3. A deep scratch will weaken the duct wall.
4. Scratches are likely to cause ducting to leak.



WRINKLES



DENTS



SCRATCHES OR GOUGES

Answers to Frame 5: 1. T 2. T 3. T 4. T

Frame 6

There are just a few things to keep in mind about ducting and its repair. When working with a screwdriver make sure it does not slip and damage the ducting or the insulation. When in doubt about allowable damage, always check the TO. Also make sure you use the proper torque on all clamps and bolts.

It is not an easy job to replace ducting, so BE CAREFUL when working with it.

No Response Required

Frame 7

Corrosion Control

Now let us see what happens to ducting if corrosion sets in and how corrosion can be slowed. Corrosion in aluminum and its alloys looks like a spot of dirty, dust-like, white powder that is on the surface of the metal. This gets progressively worse as deterioration increases, and the metal may weaken to the failure point. So, you can see why the ducting must be inspected frequently for signs of corrosion.

To slow up corrosion, several things can be done. The metal can be painted, waxed, oiled, or coated with a metal that corrodes slowly. The process used most is to coat the ducting with a metal that corrodes slowly. This process is known as anodizing, aluminum cladding, chrome plating, or copper plating to name a few.

Answer each of the statements as true (T) or false (F).

1. Corrosion appears as a dust-like white powder.
2. Corrosion can weaken the metal.
3. Ducting never needs to be inspected for corrosion.
4. Coating the metal with a metal can be called aluminum cladding.
5. Painting of the ducting slows down the corrosion process.

Answers to Frame 7: 1. T 2. T 3. F 4. T 5. T

Frame 8

Never underestimate the importance of anticorrosion precautions. Any corrosion affecting the parts of an aircraft affects the safety of an entire aircraft.

No Response



THE CORROSION MENANCE

2104

Frame 9

Cleaning Agents

Some of the types of cleaning agents used in the Air Force are Stoddard solvent, Flash solvent, Type I solvent, Type II solvent, Perchloroethylene, Tetrachloroethylene, and Trichloroethylene.

Trichloroethylene is used more than the other cleaning agents. It is used to clean oxygen parts, degrease bearings, clean motor gear trains, etc. Do not try to clean electrical wiring with trichloroethylene as the wire insulation will deteriorate. Electrical parts should be cleaned with a lint free cloth slightly moist with cleaning solvent.

Answer each of the statements as true (T) or false (F).

1. Stoddard solvent is considered to be a cleaning agent.
2. Electrical wiring may be cleaned with trichloroethylene.
3. Flash solvent is NOT a cleaning agent.
4. Type I and Type II solvents are cleaning agents.

W A R N I N G

If solvents are used in a closed space, good ventilation must be used to keep the concentration of contaminants in the air from becoming hazardous to health. The base medical service will check for the correct protective measures.

262

Answers to Frame 9: 1. T 2. F 3. F 4. T

Frame 10

Lubricants: When on the flight line you will use many different types of oil, grease and lubricants. We list a few of them that you will use.

The first one is Specification MIL-L-7645, Lubricating Grease. This is a semisolid, noncorrosive, mild extreme pressure lubricant. It is used for gears, screws and threaded parts. It is used for greater loads than petroleum oils. The grease is not an extreme pressure or "Hypoid" lubricant.

Specification MIL-G-4343, Grease, Pneumatic System is used as a lubricant between rubber and metal parts. It may be used for pneumatic systems, pressurized cabin bulkhead grommets and other mechanisms.

Answer each of the statements as true (T) or false (F).

1. Specification MIL-L-7645 is a single-grade of aircraft turbine lubricating oil.
2. MIL-G-4343 may be used for lubricating grommets between pressurized cabin bulkheads.
3. MIL-L-7645 is a noncorrosive lubricant.
4. MIL-L-7645 is considered to be very corrosive.

Answers to Frame 10: 1. F 2. T 3. T 4. F

Frame 11

Two of the most used lubricating oils are Specification MIL-L-007808F and MIL-L-6085. Specification MIL-L-007808F lists oils of a single-grade. These oils are used in turbine engines and helicopter transmissions. Specification MIL-L-6085 lists oils that are used in aircraft instruments, electronic equipment, or where low evaporation oil is required for both high and low temperature operations. These oils can be used where oxidation and corrosion resistance is desirable.

Answer each of the statements as true (T) or false (F).

1. MIL-L-007808F lubricating oil covers a single-grade of aircraft - turbine lubricating oil.
2. MIL-L-007808F lubricating oil is intended for use in specific turbine engines and helicopter transmissions.
3. MIL-L-6085 is considered to be a low evaporating lubricating oil.
4. MIL-L-6085 lubricating oil may not be used where high or low temperatures are applicable.
5. MIL-L-6085 lubricating oil is not a corrosion resistance oil.

Answers to Frame 11: 1. T 2. T 3. T 4. F 5. F

Frame 12

Keep in mind, these are not all of the lubricants that are used in the Air Force. When you need any lubricant for repair jobs, refer to a technical order for the correct specification.

No Response Required

Environmental Pneudraulic Branch
Chanute AFB, Illinois

3ABR42331-WB-305
16 October 1975

MAINTENANCE OF BLEED AIR DISTRIBUTION DUCTING

OBJECTIVES

Given a section of aircraft ducting, inspect for corrosion, nicks, scratches, and cracks, identifying three discrepancies on completion of the inspection.

EQUIPMENT

Section of Aircraft Ducting

Basis of Issue
1/student

PROCEDURE

Inspect the section of ducting that was given to you by the instructor. In the spaces below, list at least three discrepancies found on the ducting. When you have finished, return the ducting and this workbook to the instructor and point out each discrepancy to him.

List of Discrepancies

1. _____
2. _____
3. _____

OPR: TAS
DISTRIBUTION: X
TAS - 150; TTVGC - 2

Designed for ATC Course Use. Do Not Use on the Job.

Technical Training

Aircraft Environmental Systems Mechanic

AIR TURBINE MOTORS

28 July 1978



CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system. The material contained herein has been validated using 30 students enrolled in the 3ABR42331 course. Eighty percent of the students taking this text surpassed the criteria called for in the approved lesson objectives. The average student required one hour to complete the text.

OBJECTIVES

1. Identify procedures used in bench checking components of the air turbine motor with a minimum accuracy of 80%.
2. Identify general principles pertaining to the operation of an air turbine motor with a minimum accuracy of 80%.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each frame you are asked to respond by selecting one or more correct statements or by entering "T" (true) or "F" (false) in the appropriate blank. After you have made your response, compare your answer with the correct answer that is given on the next even numbered page following each frame. If your response is incorrect, restudy the frame to get the information correctly in your mind. DO NOT MARK IN THIS TEXT.

INTRODUCTION

While working as an Environmental System Specialist, you will be required to maintain air turbine motor systems installed on various types of aircraft. This text describes a typical air turbine motor. It also describes what an air turbine motor is used for and the principles of operation.

Supersedes 3ABR42231-PT-404, 8 August 1974.

OPR: 3370 TCHTG

DISTRIBUTION: X

3370TCHTG/TTGU-P - 300; TTVSA - 1

The Air Turbine Motor (ATM), is a motor driven by air pressure directed against the curved vanes of a wheel. This wheel is connected to a series of gears which are used to drive any of the following components: alternators, generators, and/or hydraulic pumps. (Refer to figure 1 below.)

The primary purpose of the air turbine motor is for an emergency source of electrical power or hydraulic pressure during in-flight emergencies. It may also be used for a source of auxiliary electrical power or hydraulic pressure during ground operation. Not all aircraft are equipped with an air turbine motor.

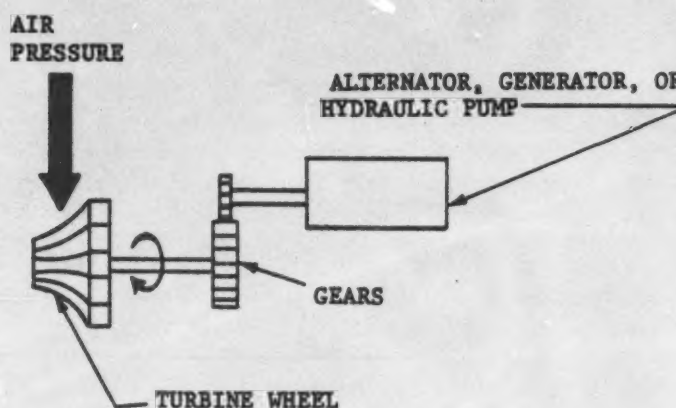


Figure 1.

Answer the following statements TRUE or FALSE.

- ___ 1. The air turbine motor is driven by an electrical motor.
- ___ 2. The primary purpose of the air turbine motor is for an emergency source of electrical power and/or hydraulic pressure.
- ___ 3. All aircraft are equipped with an air turbine motor.

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Correct Responses to Frame 1: F 1. T 2. F 3.

Note: From this time on, the text will refer to the air turbine motor as ATM.

Frame 2

The sources of air that are used to drive the ATM are as follows:

1. Engine Bleed Air (EBA) for ground or flight operation.
2. Gas Turbine Compressor (GTC) for ground operation on some aircraft.
3. Ground Air Cart (MA-1A) for ground operation ONLY.

Answer the following statements TRUE or FALSE.

1. The MA-1A is used to drive the ATM during flight operation.
2. The GTC provides air to drive the ATM during ground operation on some aircraft.
3. EBA can be used to drive the ATM for both ground and flight operation.
4. The abbreviation for Air Turbine Motor is ATM.

Frame 3

In order to understand the complete operation of the ATM, you must understand the operation of the basic parts making up the ATM. The basic parts of the ATM consists of; a turbine wheel, gear box assembly, and a speed control system. Before we discuss the operation of the ATM, we will first discuss the basic parts and their operation.

NO RESPONSE REQUIRED

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Let us first discuss the turbine wheel. By now you should be familiar with the principles of a turbine wheel. If you remember from previous blocks of instruction, a turbine wheel is a curved vane wheel. The turbine wheel will rotate when a pressurized air flow is directed on it. The turbine wheel of the ATM is connected to a series of gears within the ATM gear box (the gear box will be discussed in a later frame).

The turbine volute (turbine wheel housing) encloses the turbine wheel. (Refer to figure 2.) A pressurized air source is applied to the turbine volute inlet. The volute directs the air flow to the turbine wheel vanes. The turbine wheel will then rotate, turning the gears inside the ATM gear box.

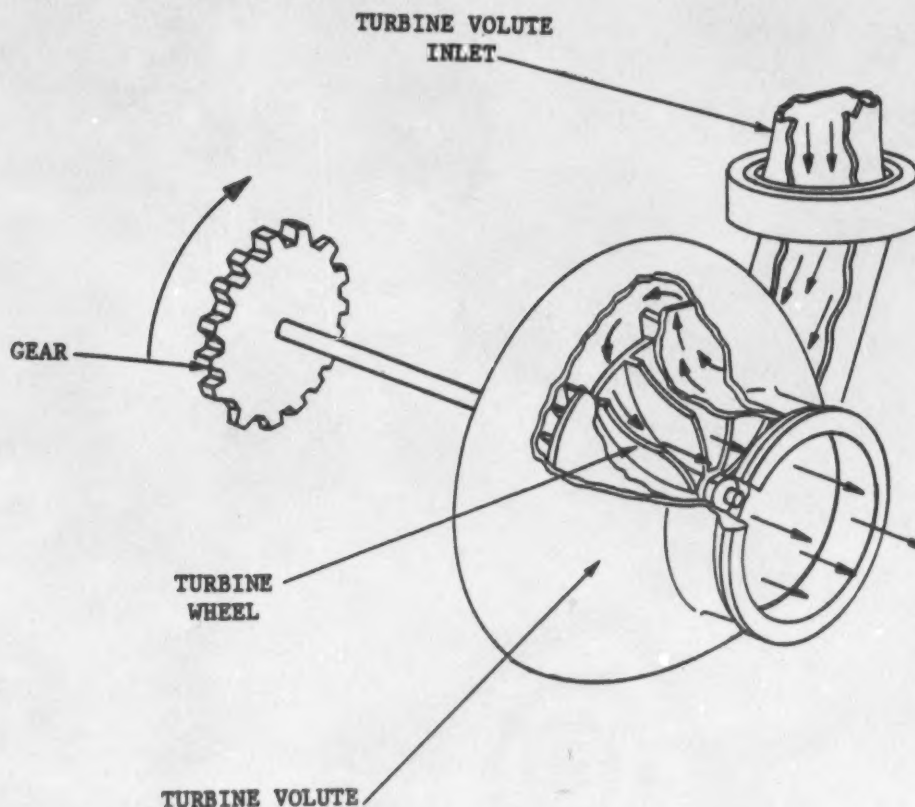


Figure 2.

Answer the following statements TRUE or FALSE.

- ___ 1. The turbine volute houses the turbine wheel.
- ___ 2. The turbine wheel drives a series of gears in the ATM gear box.

2114

Correct Responses to Frame 2: F 1. T 2. T 3. T 4.

Correct Response to Frame 3: None required.

Correct Responses to Frame 4: T 1. T 2.

Frame 5

The ATM gear box houses a series of gears (gear train). This gear train is a reduction type. There are two output drive pads that are driven by the gear train. (Refer to figure 3.) The upper output drive pad is used to drive an alternator or generator (depending on the type of aircraft the ATM is installed on). The lower output pad is used to drive a hydraulic pump. The turbine wheel turns at a controlled speed of 43,000 RPM. The speed control system (which will be discussed in a later frame) controls the turbine wheel speed. The upper output drive pad will drive an alternator or generator at a speed of 6,000 RPM. The lower output pad will drive a hydraulic pump at a speed of 3,500 RPM. The two output drive pad speeds are reduced by a reduction type gear train.

Answer the following statements TRUE or FALSE.

- 1. The alternator or generator is driven at 6,000 RPM.
- 2. The hydraulic pump is driven at 3,500 RPM.
- 3. The turbine wheel is turning at 43,000 RPM.

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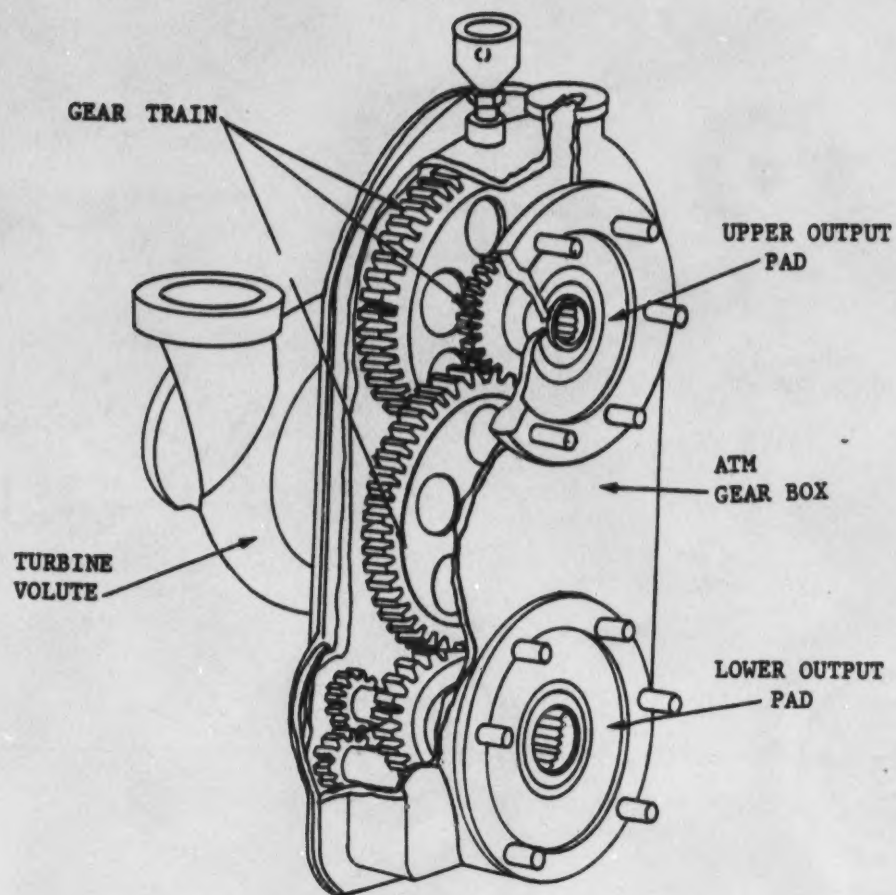


Figure 3.

Correct Responses to Frame 5: T 1. T 2. T 3.

Frame 6

The ATM has an internal oil supply. Oil is taken from the bottom of the ATM gear box by an oil pump. The oil is forced through an oil filter and then through an oil cooler. The oil cooler works on the same principles as a radiator in a car. The oil passes through tubing which cooling air flows across. The cooling air is forced in through the bottom of the oil cooler, over the oil cooling lines, and then out the oil cooler air outlet. (Refer to figure 4A.)

Note: Cooling air is supplied by ram air during flight or an ATM cooling fan during ground operation.

The cooled oil is then directed to the ATM gears and bearings inside the gear box. The oil then falls back down to the bottom of the ATM gear box and is recirculated again. The ATM has a filler cap and an oil level sight gage for servicing the ATM with oil. The ATM must always be properly serviced with the proper amount and type of oil to prevent internal damage. The ATM is serviced with Military Specification MIL-L-23699 type oil when the oil level reached the ADD mark on the lower sight gage. (Refer to figure 4.) The oil is poured in the ATM filler port until the oil level reaches the FULL mark on the upper sight gage.

Caution: Never overfill the ATM with oil.

Answer the following statements TRUE or FALSE.

1. Oil for the ATM is taken from the engine oil supply.
2. Oil is directed through the ATM by an oil pump.
3. Military Specification MIL-L-6808 is used in the ATM.
4. An oil cooler is used to cool the ATM oil.
5. When the ATM oil level is below the FULL mark but not to the ADD mark, the ATM must be serviced with oil.

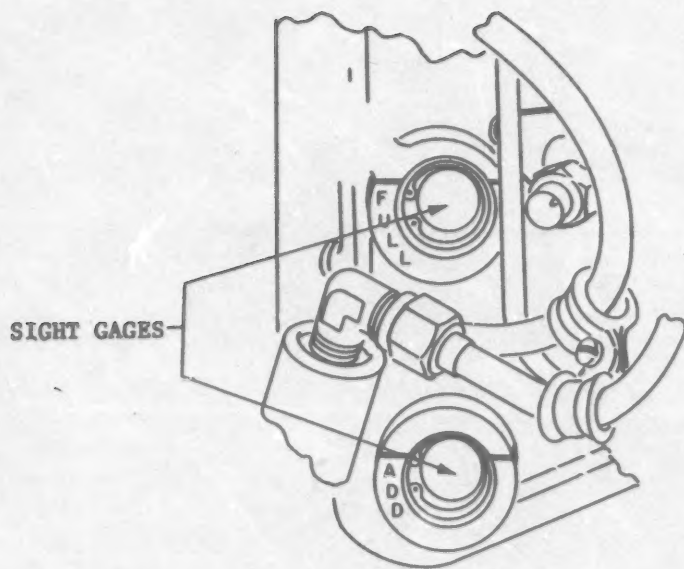


Figure 4.

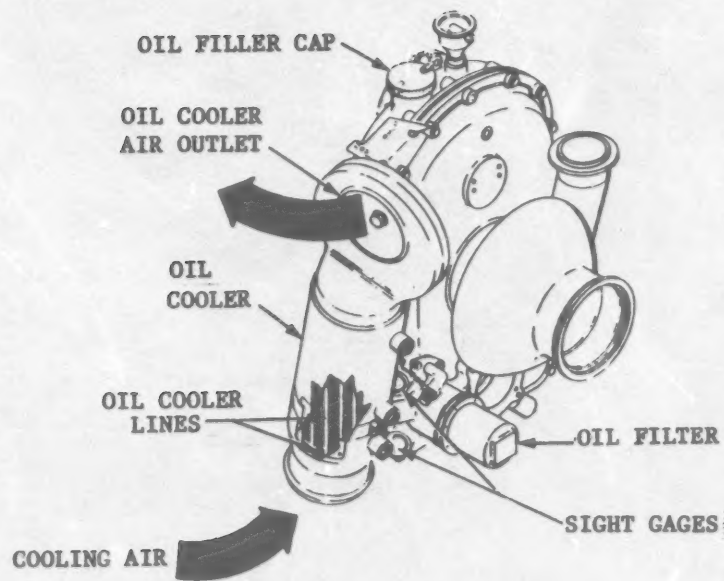


Figure 4A.

Correct Responses to Frame 6: F 1. T 2. F 3. T 4. F 5.

Frame 7

The ATM is a pneumatically operated motor. This means it is operated by air pressure. Air pressure, from the aircraft bleed air system, enters the ATM at the AIR INLET. (Refer to figure 5.) The air entering the ATM is controlled by a shutoff valve and a modulating valve. Some of the air entering the ATM air inlet is tapped off before the shutoff valve butterfly. This air is then directed, by metal tubing, to the shutoff valve actuator opening diaphragm, solenoid valve, and overspeed trip assembly. Some air is also tapped off between the shutoff valve and the modulating valve butterfly. This air goes through the oil cooler, moisture separator, air filter, and pressure regulator. The air is then directed to the compensating diaphragm of the modulating valve actuator (mod valve actuator). The air is also directed through the speed controller to the actuating diaphragm of the mod valve actuator. When the shutoff valve and mod valve butterflies open, the bleed air is directed through the turbine volute. The turbine volute directs the air to the turbine wheel, then out the turbine exhaust.

Answer the following statements TRUE or FALSE.

- 1. The ATM is electrically operated.
- 2. Air from the speed controller goes to the actuating diaphragm of the modulating valve.
- 3. The air that goes to the modulating valve actuator, goes through the oil cooler first.

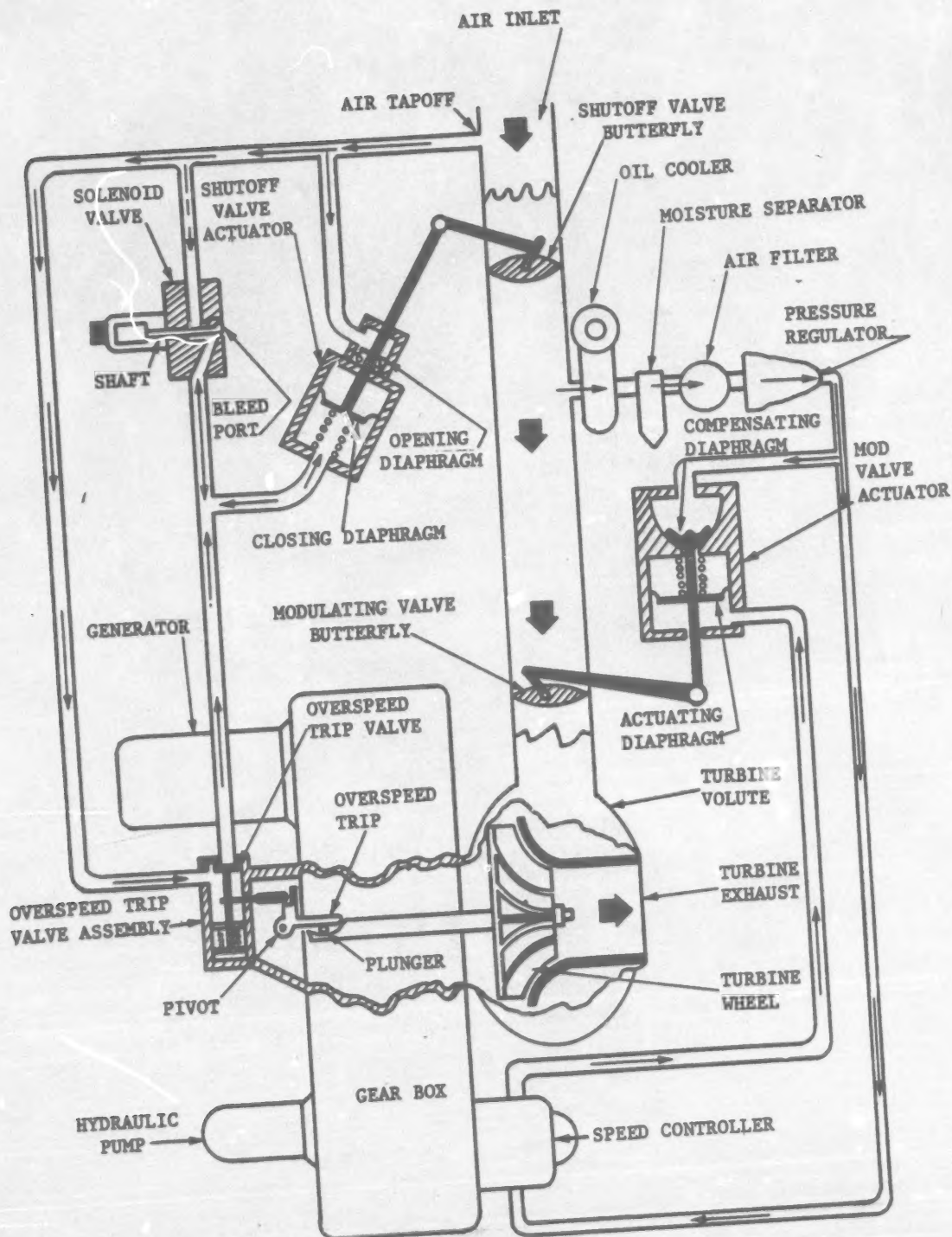


Figure 5.
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Correct Responses to Frame 7: F 1. T 2. T 3.

Frame 8

At the beginning of this text, we stated that the ATM drives two output pads. The upper pad at 6,000 RPM and the lower pad at 3,500 RPM. This speed must be constant or the components attached to them will not work correctly. If there was no way to control the airflow that is directed to the turbine wheel, the turbine wheel speed would not be constant. This would directly affect the speed of the two output pads. For example: If the aircraft engines were running at idle speed, they would produce a lower pressure of bleed air. This would make the ATM turbine wheel turn at a low RPM. If the aircraft engines were then accelerated, the bleed air pressure would increase. This would make the ATM turbine wheel turn faster. Since the two output pads are driven through a series of gears, by the turbine wheel, the output pads speed would also vary. Therefore, we must have some way to control the amount of air pressure to the turbine wheel to control the output pad speed. In the following frames we will discuss how the ATM speed is controlled.

Answer the following statements TRUE or FALSE.

1. To control the output pad speed, the air pressure to the turbine wheel must be controlled.
2. Air pressure to the ATM inlet will always be at a constant pressure.

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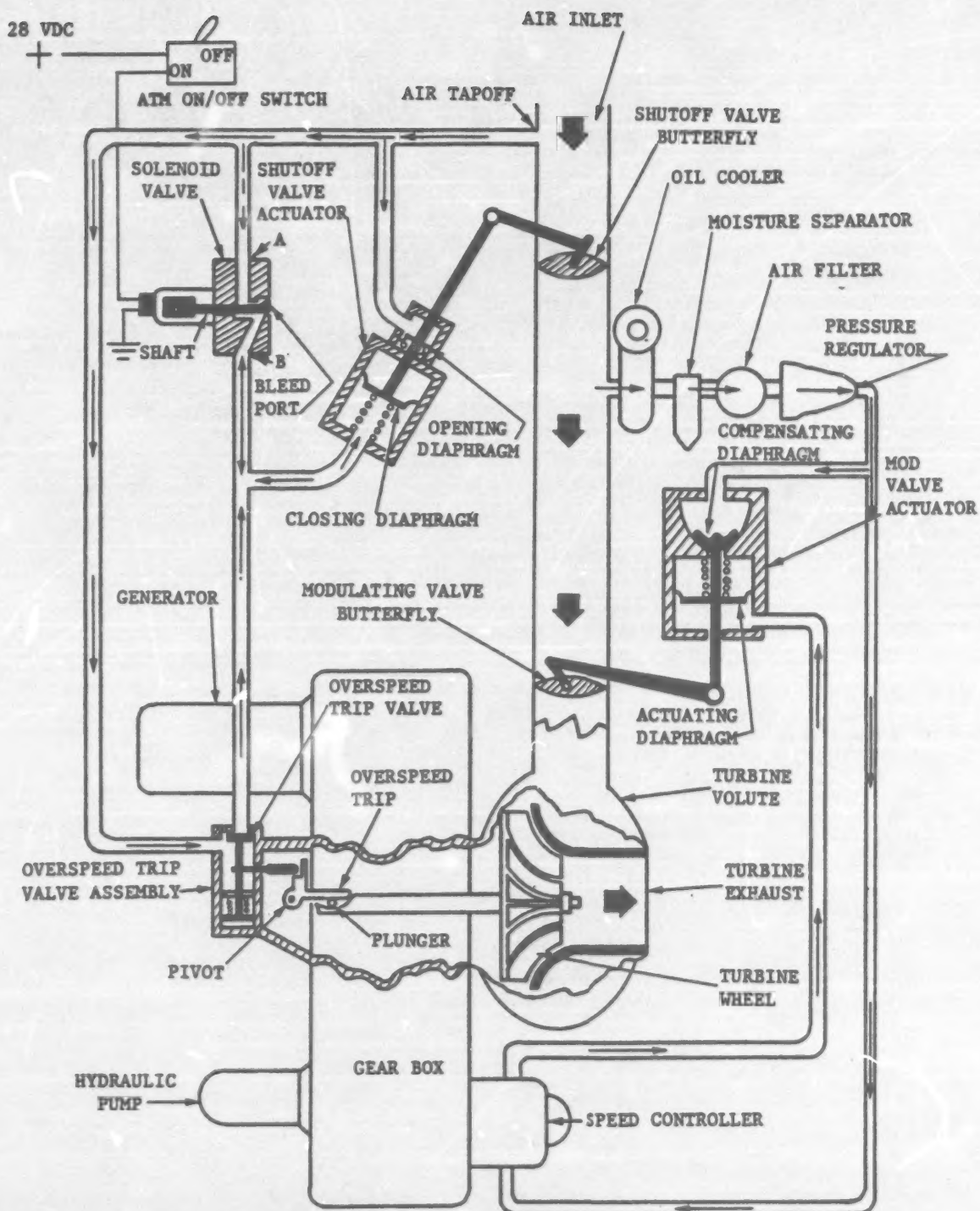


Figure 6.
13

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Correct Responses to Frame 8: T 1. F 2.

Frame 9

The first of our discussion will be those components that control the air pressure to the ATM turbine wheel. The air that enters the ATM is directly controlled by the ATM shutoff valve butterfly. (Refer to figure 6.) When an air source is applied to the ATM air inlet, the flow is stopped due to the ATM shutoff valve butterfly being closed. This valve is spring-loaded to the close position. Just above the ATM shutoff valve butterfly, air is directed (by an air tapoff) to the opening diaphragm of the ATM shutoff valve actuator and the solenoid valve. The solenoid valve is electrically controlled by the ATM ON/OFF switch. This switch is located in the crew compartment of the aircraft. When the ATM ON/OFF switch is placed to the OFF position, there will be no electrical power applied to the solenoid valve. Without electrical power, the solenoid is deenergized. This action closes off the bleed port and opens the inlet port (A) of the solenoid valve. Now, air entering port A, passes through the deenergized solenoid valve to port B. This air is then directed to the closing diaphragm of the ATM shutoff valve actuator. The air pressure, along with the spring tension on the closing diaphragm, will keep the shutoff valve butterfly closed. Since no air pressure can reach the ATM turbine wheel, the ATM will not operate.

Answer the following statements TRUE or FALSE.

1. The air pressure which is directed to the ATM shutoff valve actuator is tapped off below the ATM shutoff valve butterfly.
2. The ATM will not operate when the solenoid valve is deenergized.

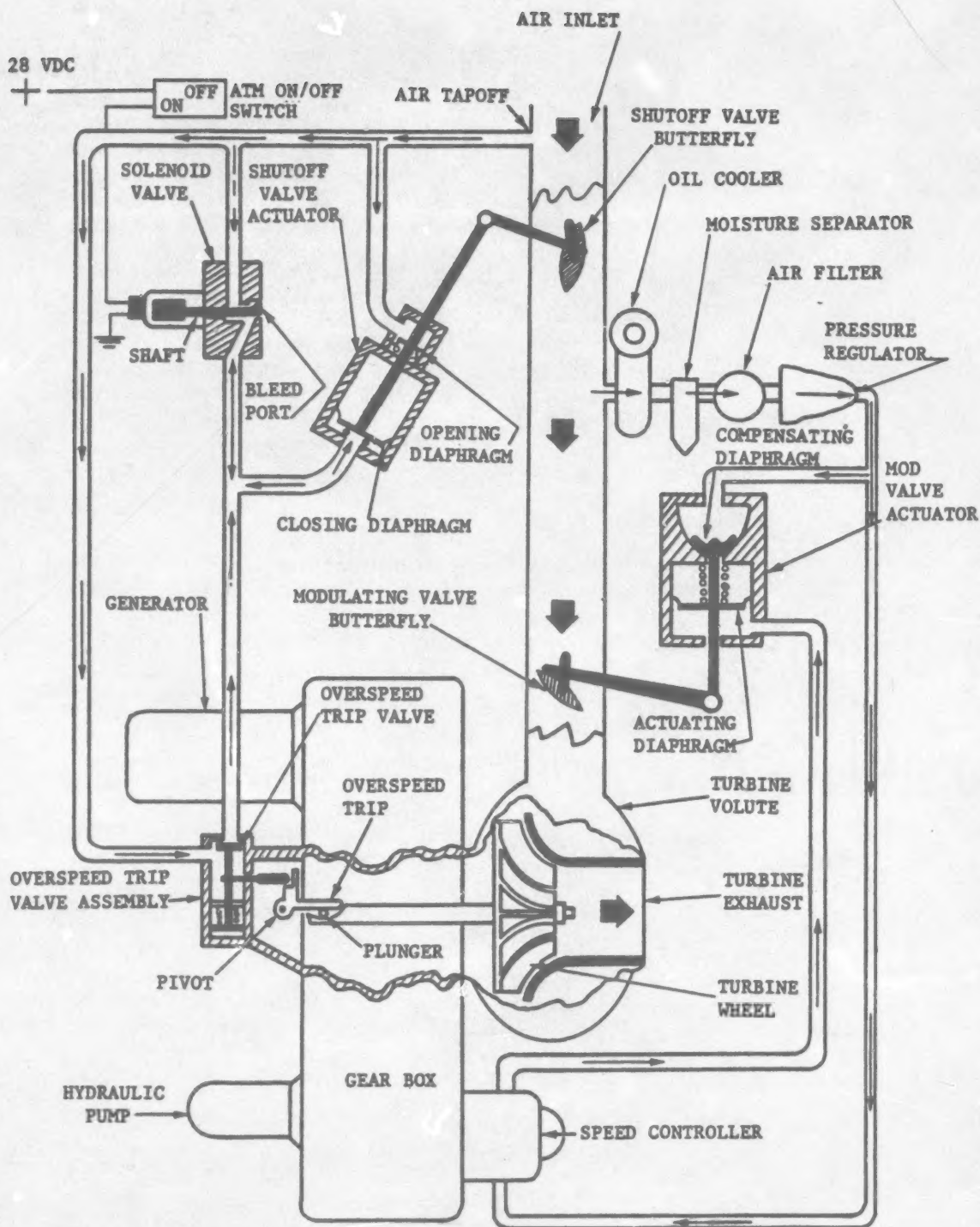


Figure 7.
15

Correct Responses to Frame 9: F 1. T 2.

Frame 10

When the ATM ON/OFF switch is in the ON position, (refer to figure 7) the solenoid valve energizes. Its shaft is drawn to the left, thereby opening its bleed port. This dumps the air pressure from the bottom of the closing diaphragm out through the open bleed port. Now, the force of the air on the top of the opening diaphragm will be enough to move the shutoff valve actuator downward. This, in turn, causes the butterfly valve to open and allow airflow to enter the ATM. Just below the shutoff valve butterfly, air pressure enters a tapoff and passes through the oil cooler. This oil cooler is a heat exchanger that serves two functions. It cools the lubricating oil from the gear box and it cools the air flow that passes through it. Ram air is the cooling agent. Once the air has been cooled, it passes through a moisture separator, air filter, and pressure regulator. The moisture separator eliminates any small particles of water from the air before it passes into the air filter. The air filter removes small particles of dust and dirt from the air. The pressure regulator regulates the air flow to a maximum 55 psig to the compensating diaphragm and speed controller.

Answer the following statements TRUE or FALSE.

- 1. The solenoid valve starts and stops the ATM.
- 2. The pressure regulator regulates pressure to the compensating diaphragm and speed controller to 55 psig.
- 3. The oil cooler cools air going to the solenoid and shutoff valves.

Frame 11

The speed controller (in figure 7) controls the air flow to the mod valve actuating diaphragm. The speed controller is driven by the turbine wheel through a series of gears. When the turbine wheel speed increases, the speed controller decreases the air flow applied to the mod valve actuating diaphragm. This, in turn, causes the modulating valve actuator to move the butterfly toward the close position. By closing the butterfly, the amount of air flow to the turbine wheel is decreased allowing the turbine wheel to slow down. As the turbine wheel decreases speed, the speed controller allows an increase in air pressure to the mod valve actuating diaphragm. The actuator will again cause the modulating valve butterfly to move toward the open position. This will increase air flow to the turbine wheel, thus, increasing its speed. In this way, the speed controller will control the turbine speed at 43,000 RPM.

Answer the following statements TRUE or FALSE.

- ____ 1. The air pressure against the actuating diaphragm is controlled by the speed controller.
- ____ 2. The force of the air pressure from the speed controller against the actuating diaphragm opens the modulating valve butterfly.
- ____ 3. The purpose of the speed controller is to govern turbine wheel speed.
- ____ 4. The modulating valve actuator operates the modulating valve butterfly.

Frame 12

If the turbine wheel speed increases to a critical range of 52,000 to 56,000 RPM, centrifugal force causes a plunger on the turbine wheel shaft to move upward. (Refer to figure 8.) This causes the overspeed trip to rotate counterclockwise on its pivot. The overspeed trip forces the overspeed trip valve down and opens the overspeed trip valve port. Opening this port allows air pressure from the tapoff to be applied to the shutoff valve actuator closing diaphragm. When this air pressure is applied, the shutoff valve closes. This stops ATM operation, even though the solenoid valve small bleed port is still open. The overspeed trip valve must be reset after repairs are made.

Answer the following statements TRUE or FALSE.

- ____ 1. Closing of the shutoff valve butterfly results in stopping ATM operation.
- ____ 2. When turbine wheel speed reaches a speed between 52,000 to 56,000 RPM the overspeed trip valve port opens.
- ____ 3. The overspeed trip plunger is operated by centrifugal force.

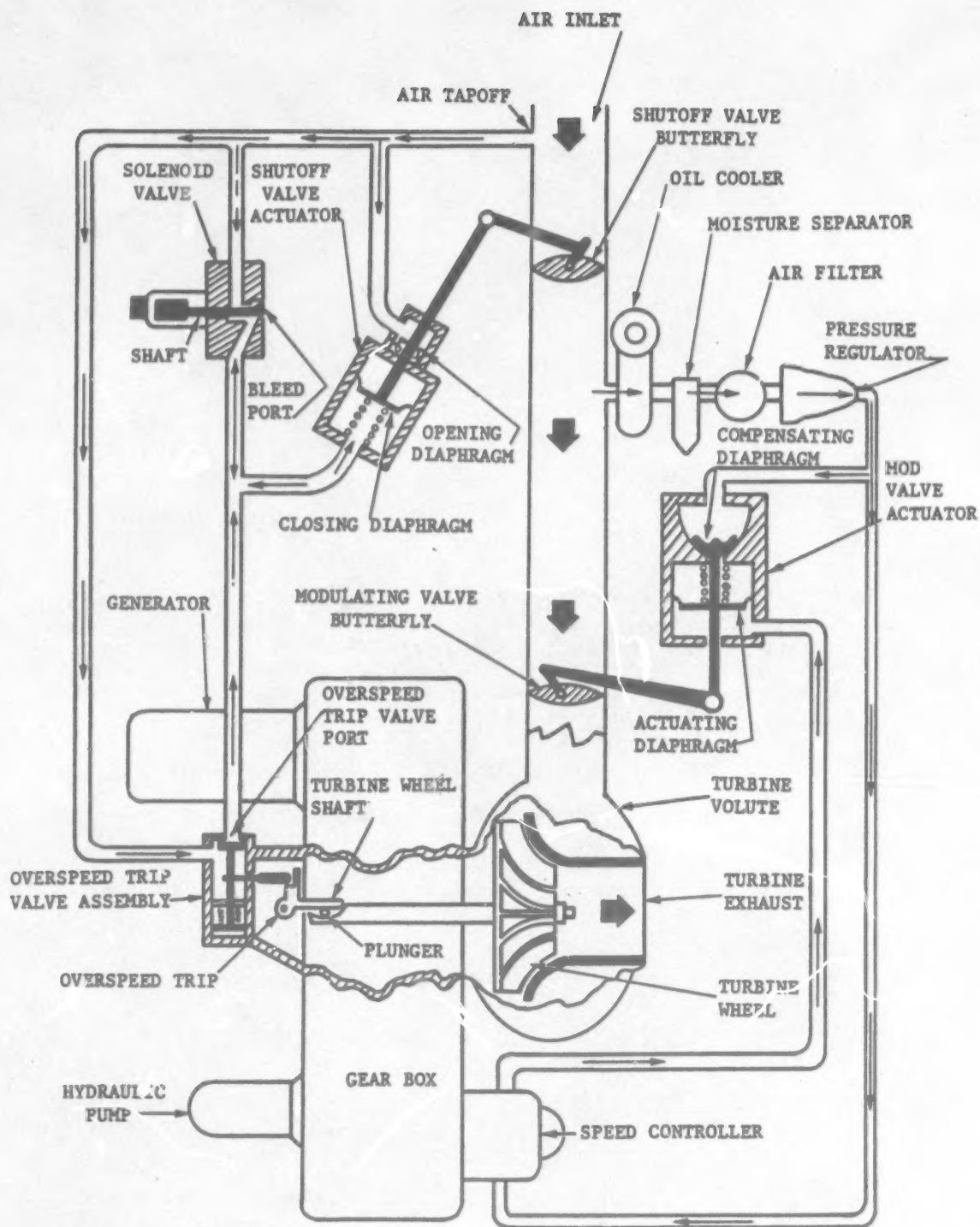


Figure 8.
18

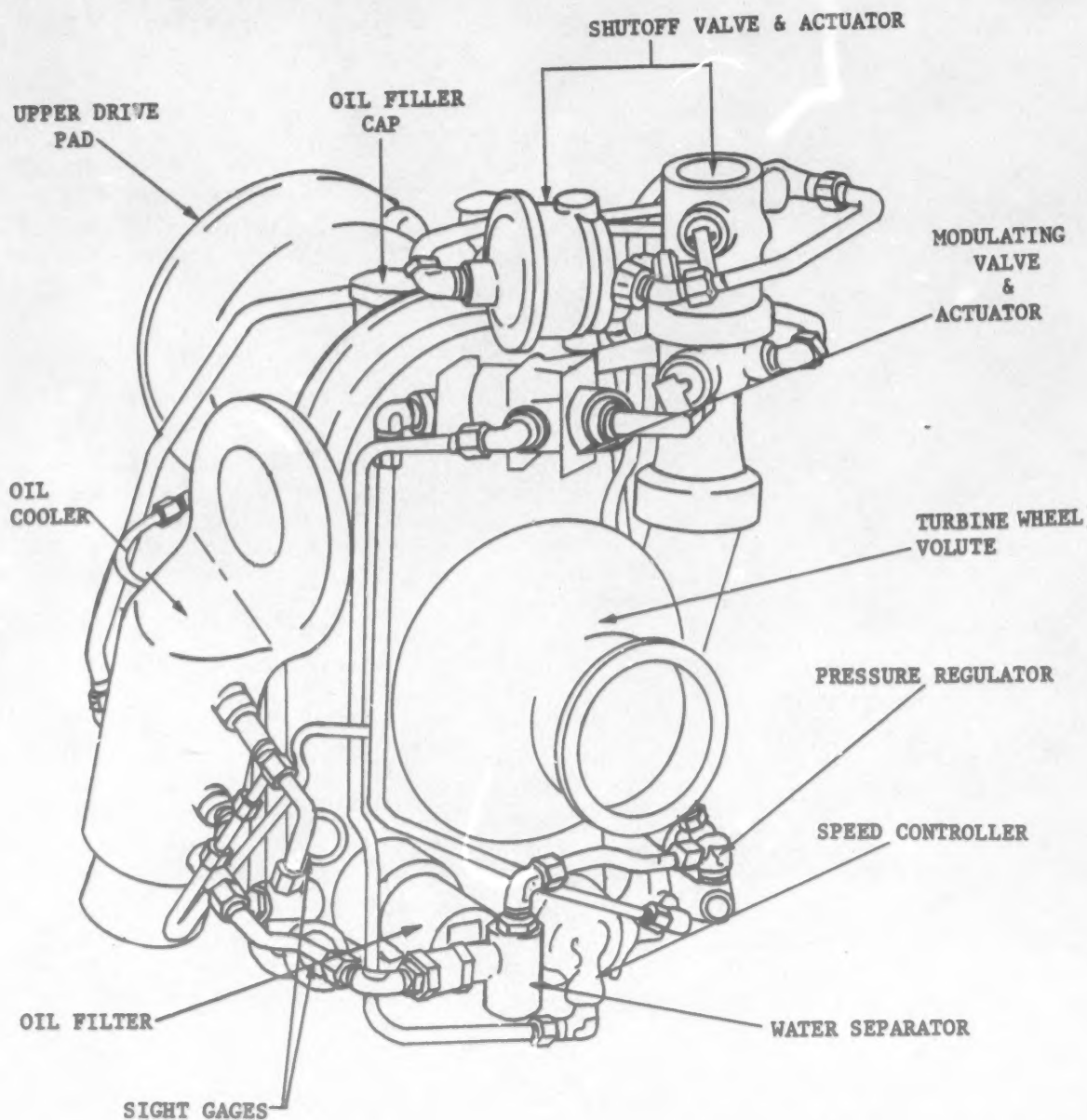


Figure 9.

Correct Responses to Frame 10: T 1. T 2. F 3.
 Correct Responses to Frame 11: T 1. T 2. T 3. T 4.
 Correct Responses to Frame 12: T 1. T 2. T 3.

Frame 13

It is important that you become familiar with the procedures used in bench checking the components of the ATM. First the ATM must be removed from the aircraft and mounted on a test stand. Electrical power and bleed air are required, however, most checks are made with power and air off.

1. The solenoid valve - with 28VDC and air applied - can be checked by operating the on and off switch. In the on position the linkage should be fully retracted and with the switch in the off position the linkage should be fully extended.

2. The shutoff valve - power and air must be off for this check. The shutoff valve linkage must be free of binding and sticking and should move approximately 1" from the closed to open position. This check is made by moving the linkage by hand.

The opening diaphragm can be checked for leakage by moving the linkage to the open position by hand and by using a finger to cover the vent hole located on the bottom of the valve housing. If the diaphragm does not leak, the linkage will remain in the full open position as long as your finger is covering the vent hole. When your finger is removed from the vent hole, the linkage should return to the full closed position.

3. The overspeed trip valve - with power and air off - must be in the reset or closed position for the ATM to operate. Check by pressing in slowly on the overspeed reset button until the plunger is in as far as it will go. This will ensure that the ATM is NOT in an overspeed condition.

4. The pressure regulator - with power and air on - can be checked by using a pressure gauge installed between the pressure regulator and the modulating valve. Pressure should be 55 PSI during operation of the ATM.

5. The speed controller, with power and air off, can only be checked visually for noticable damage. Its internal parts can be checked by removing it from the ATM and placing it on a special test stand.

6. The modulating valve, with power and air off, can be checked for freedom of movement by moving the linkage full open and closed by hand. Checking of the diaphragms cannot be done without disassembly of the valve.

Answer the following statements TRUE or FALSE.

1. The solenoid valve linkage should be fully extended when the switch is off.
2. The ATM shutoff valve must be able to move 2" for proper operation.
3. Pressing in the overspeed trip valve button ensures that there is an overspeed condition.
4. The ATM pressure regulator should maintain 65 PSI.
5. The modulating valve linkage can be checked for freedom of movement in the same way as the shutoff valve.

Correct Responses to Frame 13: T 1. F 2. F 3. F 4.
T 5.

Frame 14

By now you should know the general principles of operation of the ATM and the procedures for bench checking its components. You should also be able to identify and locate the different components that make up the ATM. Figure 9 is an external view of the ATM. Study figure 9 and identify by name each component indicated. This should enable you to easily locate components for bench checking and troubleshooting the ATM.

NO RESPONSE REQUIRED

AIR TURBINE MOTOR (ATM)

Frame 1

___ 1.

___ 2.

___ 3.

Frame 2

___ 1.

___ 2.

___ 3.

___ 4.

Frame 3

No Response Required

Frame 4

___ 1.

___ 2.

Frame 5

___ 1.

___ 2.

___ 3.

Frame 6

___ 1.

___ 2.

___ 3.

___ 4.

___ 5.

Frame 7

___ 1.

___ 2.

___ 3.

Frame 8

___ 1.

___ 2.

Frame 9

___ 1.

___ 2.

Frame 10

___ 1.

___ 2.

___ 3.

Frame 11

___ 1.

___ 2.

___ 3.

___ 4.

Frame 12

___ 1.

___ 2.

___ 3.

Frame 13

No Response Required

Frame 13

___ 1.

___ 2.

___ 3.

___ 4.

___ 5.

Frame 14

No Response Required

MAINTENANCE OF AIR TURBINE MOTORS

OBJECTIVES

1. Using an inspection workcard and maintenance data collection forms, inspect an air turbine motor recording a minimum of three discrepancies.
2. Using a ground air cart and maintenance data collection forms, perform an operational check of the air turbine motor.

EQUIPMENT

Air Turbine Motor
MA-1A Ground Air Cart

Basis of Issue
1/student
1/student

PROCEDURE

This workbook has three projects for you to complete. In project 1 you will inspect an ATM. Project 2 has you doing preliminary items that are required for an operational check and then performing the operational check. Project 3 takes you through the ATM and MA-1A shutdown procedures. Follow the instructions given to you in each of the projects. Your lab instructor is also required to check you on application of ground safety practices. Be careful and follow those safety precautions taught you in block I.

Project 1

Your laboratory instructor will give you an AFTO Form 26 and Maintenance Data Collection forms (AFTO Forms 349). You will perform an inspection on the C-130 ATM and record the discrepancies on the AFTO Forms 349. Use the -06 code manual provided by your instructor to complete your AFTO Forms 349. Your laboratory instructor will check your work before going any further into the workbook. A minimum of three (3) discrepancies must be found and documented.

Supersedes 3ABR42331-WB-316, 7 December 1977.

OPR: 3370 TCHTG

DISTRIBUTION: X

3370TCHTG/TTGU-P - 500; TTVSA - 1

Designed for ATC Course Use. Do Not Use on the Job.

Project 2

1. Prior to the operational check, complete the items listed below and check them off as you complete them.

a. Connect control box, on the wall, to a 28V DC outlet on the right side of the load bank workbench. _____

b. Connect load bank workbench to a 28V DC outlet on the wall, left side of load bank workbench. _____

c. Turn the C-130 switch, on the control box, to the open position. _____

d. Connect the ATM to a 28V DC outlet on the left side of the load bank workbench. _____

e. Make sure all circuit breakers are pushed in and ATM control switch on the ATM is off. _____

2. Proceed outside with your laboratory instructor and complete the following checklist for operation of the MA-1A ground air cart. WEAR EAR PROTECTION WHEN NECESSARY. The instructor will assist you.

a. Remove the protective cover from the unit. _____

b. Check the unit fuel and oil levels. _____

c. Make the required entries in the unit forms. _____

d. Lay the air output hose straight out on the ground. _____

e. Start the unit and when the light comes on, momentarily turn the air output switch on. (This removes any kinks from the air supply line.) _____

f. Shut down the unit and connect the air output hose to the connection on the side of the building. _____

g. Turn on the master and air output switches of the MA-1A. _____

3. After the checklist has been completed, proceed to the ATM laboratory to perform the following steps in sequence, and check them off as they are completed. Observe all safety precautions.

a. ATM mounting secure. _____

b. ATM drain plug and filter plug tight. _____

c. Pneumatic ducts in place and secured. _____

4. Operational check

a. WEAR EAR PROTECTORS.

b. Turn ATM switch on, located on the side of the ATM.

c. Observe and indicate in the blanks below the action of the following:

EXAMPLE:(1) Solenoid, air coming from bleed port.

Complete the next three on your own.

(1) Shutoff valve, _____

(2) Modulating valve, _____

(3) Generator, _____

Project 3

1. Shutdown procedures.

a. Use checklist below and check off each step as you complete it.

b. Turn the ATM switch off. _____

c. Unplug the ATM from load bank workbench. _____

d. Turn the C-130 switch to the closed position, located on the wall. _____

e. Unplug the switch control box, located on the wall, from load bank workbench. _____

f. Unplug the load bank from the wall outlet. _____

g. Wipe all traces of oil from the ATM and ATM oil pan. _____

Proceed outside to complete this part of the checklist.

h. Turn off the "Master" and "Air Output" switches on the MA-1A. _____

i. Disconnect the air inlet hose from the side of the building and wind it on the cart. _____

j. Close all doors on the MA-1A. _____

k. Install the protective cover on the MA-1A. _____

CARD NO.	WORK AREA(S)	TYPE MECH RGR	MECH NO.	CARD TIME	PUBLICATION NUMBER AND DATE	CHANGE RECORD
MAN MINUTES	WORK AREA	WORK UNIT CODE FOR DISCREPANCY		INSPECTION REQUIREMENTS	ELEC POWER	SERVICE
		SYS	SUB-SYS AND CORP			

CARD NO.	WORK AREA(S)	TYPE MECH RGR	MECH NO.	CARD TIME	PUBLICATION NUMBER AND DATE	CHANGE RECORD

MAN MINUTES	WORK AREA	WORK UNIT CODE FOR DISCREPANCY		INSPECTION REQUIREMENTS	ELEC POWER	SERVICE	CARD NO.
		SYS	SUB-SYS AND CORP				

**Technical Training****Aircraft Environmental Systems Mechanic****TURBINE REFRIGERATION DEVICES****8 October 1970****CRANUTE TECHNICAL TRAINING CENTER (ATC)****This supersedes PT 3ABR42231-416, 3 December 1969.****OPR: TSDS****DISTRIBUTION: X****TSDS - 400; TSOC - 2**

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42231 Instructional System. The material contained herein has been validated using (30) 42010 students enrolled in the 3ABR42231 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 28 minutes to complete the text.

OBJECTIVES

Upon completion of this text, the student will answer 24 matching and written questions on the components and operation of:

1. An Oil Pack Turbine
2. An Oil Sump Turbine
3. A Compressor Type Turbine
4. A Variable Nozzle Turbine

A minimum of 17 of the questions must be answered correctly.

INSTRUCTIONS

This text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the true statement/statements from the list. The answers to the correct statements can be found on the top of the next page. If you selected the correct answers, continue to the next frame.

As you read the text, the turbines will be available for you to see and inspect. If you have any questions, ask your instructor.

On today's high speed, high altitude jet aircraft, air for operating the air conditioning system for the cockpit or cabin is taken from the last stage of engine compression. This air has a very high temperature, which is usually between 600-900 degrees Fahrenheit on most aircraft. This air is known as engine bleed air. In this text and on the flight line it is simply known as "EBA." After the heat exchangers cool this EBA as much as possible it is routed to the air cooling turbine, which cools the air further by rapidly expanding the air.

In this text we will discuss the major types of turbines that are used on today's jet aircraft.

Note: Check (✓) the following statements that are true.

- ☐ 1. The abbreviation for engine bleed air is EBA.
- ☐ 2. The temperature of engine bleed air is very high.
- ☐ 3. EBA is tapped off the compressor section of the engine.
- ☐ 4. The heat exchangers cool the air before it reaches the cooling turbine.
- ☐ 5. The air is cooled by expanding it.

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Answers to Frame 1: ✓ 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5.

Frame 2

The four main types of cooling turbines used in today's aircraft are: (1) oil sump, (2) oil pack, (3) compressor type, and (4) variable nozzle. Cooling turbines are also called air cycle machines.

As the turbine units are being discussed, refer to the foldout (back of text) in order to see the location of the components.

The major components of the oil sump turbine are the turbine wheel (1) and fan assembly (6). These two units are connected by a common shaft (15). The turbine wheel is driven by EBA, by way of the nozzle ring (11), which causes a temperature drop by rapidly expanding the air on the outlet side of the turbine wheel. The turbine then drives the fan.

The fan (6) draws ram air across the heat exchanger and at the same time puts a load on the turbine to prevent the turbine from overspeeding.

Note: Check (✓) the statements that are true.

- 1. The turbine cools the air by rapidly expanding it.
- 2. The fan draws ram air across the heat exchanger.
- 3. The fan puts a load on the turbine to prevent overspeeding.
- 4. The turbine is driven by the fan.
- 5. The turbine wheel and fan assembly are connected by a common shaft.
- 6. The four main types of turbines are oil sump, oil pack, compressor, and variable nozzle.

//////////

Answers to Frame 2: ✓ 1. ✓ 2. ✓ 3. 4. ✓ 5.
✓ 6.

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Frame 3

Now that you know the function of the turbine and fan assembly, let's take a look at what the rest of the parts do.

The bearings (9 and 14) support the shaft (15). The preload spring (8) absorbs the end play of the shaft.

The oil for lubricating the bearings is stored in the sump (3). A felt blanket (5) prevents the oil from reaching the bearings in a liquid form. The oil flows slowly through the wick (4) to the blanket (5) and then to the bearings (9 and 14). The slinger rings (2) draw an oil mist from the blanket (5) across the bearings (9 and 14), then returns the oil to the sump through drilled passages. The labyrinth seals (oil seals) (10 and 13) keep the oil from getting into the cold air duct and the ram air duct.

Note: Check (✓) the following statements that are true.

- 1. The slinger rings draw oil across the bearings.
- 2. The bearings support the shaft.
- 3. The labyrinth seal keeps the oil from getting into the cold air and ram air ducts.
- 4. The felt blanket keeps the oil warm.
- 5. The felt blanket keeps the oil from reaching the bearings in liquid form.
- 6. The wick keeps the oil from reaching the felt blanket.

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2140

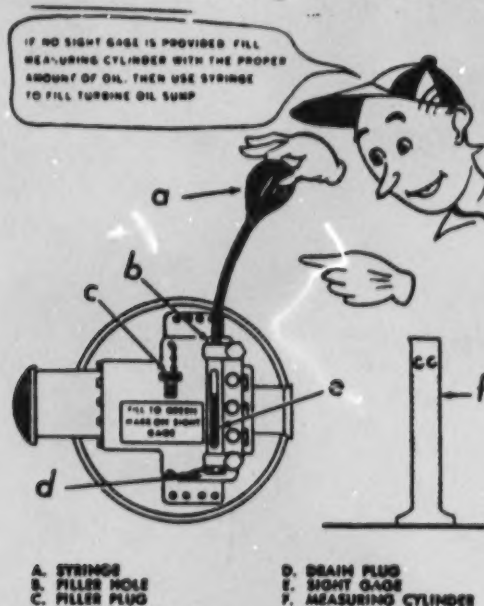
Answers to Frame 3: ✓ 1. ✓ 2. ✓ 3. 4. ✓ 5.
✓ 6.

Frame 4

Let's see how oil is added to an oil sump type turbine. The amount of oil varies with type of aircraft. You will have to look in the technical order to find the correct amount. Some aircraft turbines have sight gages, so you can tell at a glance what the oil level is. However, some turbines do not have a sight gage so the oil must be measured before it is poured into the turbine unit. For this you have to use a measuring cylinder (figure 1). It is graduated in cubic centimeters (CCs). Some aircraft also use a dipstick to check the level of oil.

Oil is changed every so many flying hours. This again varies from aircraft to aircraft and you must look in the TO for the exact time.

Important Note: Never overfill the turbine unit when adding oil. It is just as bad to overfill a turbine as it is to underfill one. Over filling will cause oil smoke to get into the cabin.



Turbine servicing.

Figure 1.

Note: Check (✓) the following statements that are true.

1. The correct amount of oil used in a turbine is found in the technical order.
2. Measuring cylinders are graduated in CCs.
3. The oil in the turbine unit is changed after so many hours of flying time.
4. Never over fill the turbine unit.

Answers to Frame 4: ✓ 1. ✓ 2. ✓ 3. ✓ 4.

2141

Frame 5

Put the foldout away and fill in the blanks in figure 2 below.

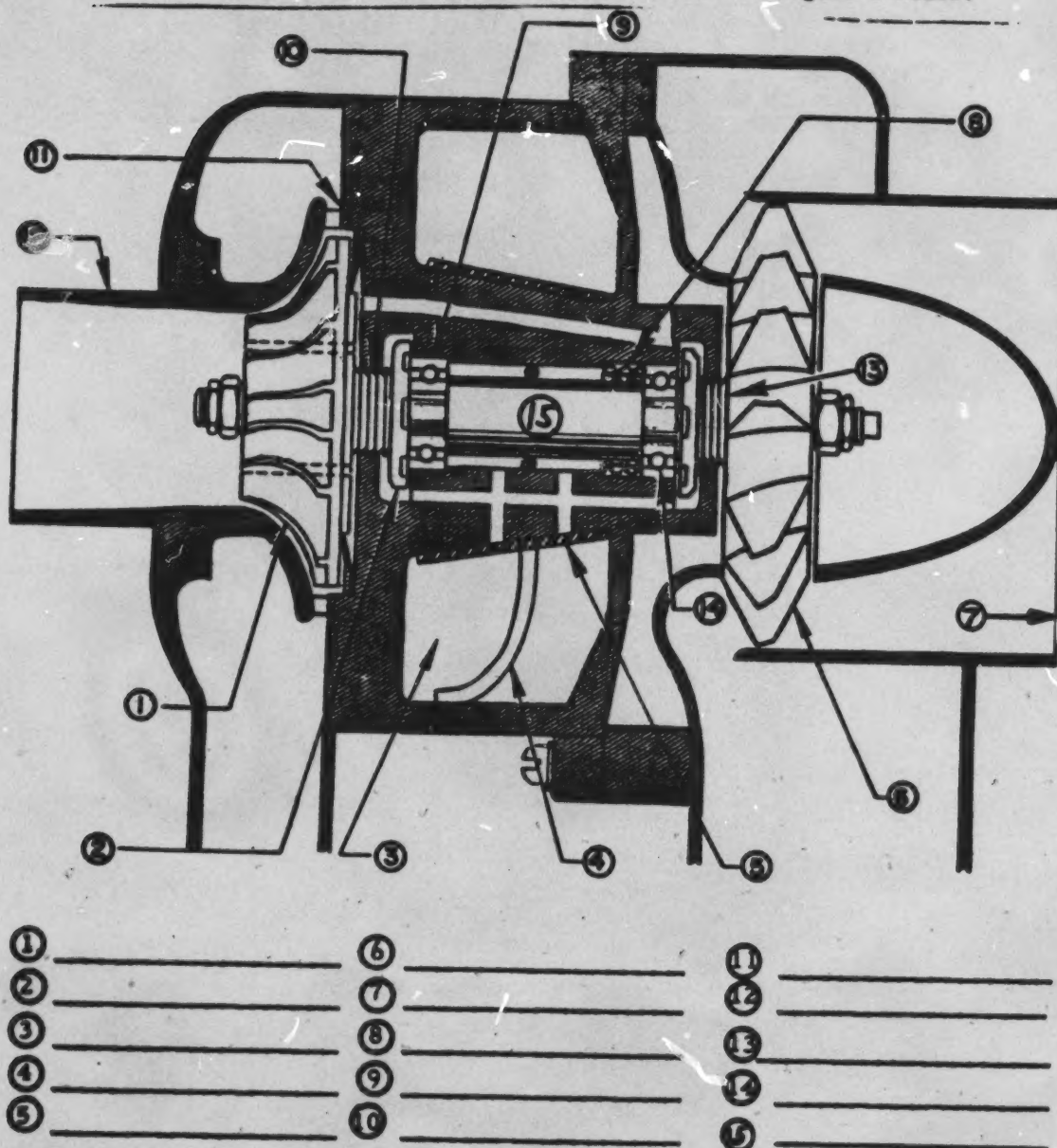


Figure 2. Oil Sump Type Turbine.

2142

Refer to the foldout in the back for the answers to Frame 5.

Frame 6

Now let's discuss the oil pack type cooling turbine that is shown in figure 3. It is much the same as the oil sump type that we have just discussed with the exception that the sump is packed with cotton.

To service the oil pack type turbine with oil you will have to observe the following procedures.

1. Remove the turbine from the aircraft.
2. Take the plug out of the drain hole.
3. Turn the turbine so the drain hole is up.
4. Add the amount of oil that the TO specified.
5. Allow the turbine to remain in that position for 20 to 30 minutes. (This allows the oil to soak into the cotton.)
6. Rotate the turbine unit so the drain hole is down.
7. Allow to remain in this position for 20 to 30 minutes, this drains the excessive oil.
8. Install drain plug and install turbine in the aircraft.

Note: Check (✓) following statements that are true.

- ☐ 1. The oil pack type turbine is lubricated by soaking cotton in the sump with oil.
- ☐ 2. The cotton is soaked for 20 to 30 minutes.
- ☐ 3. The cotton is drained for 20 to 30 minutes.
- ☐ 4. The oil pack type turbine is basically the same as the sump type.
- ☐ 5. The oil in an oil pack is serviced through the fill hole of the unit.
- ☐ 6. The amount of oil is specified in the TO.

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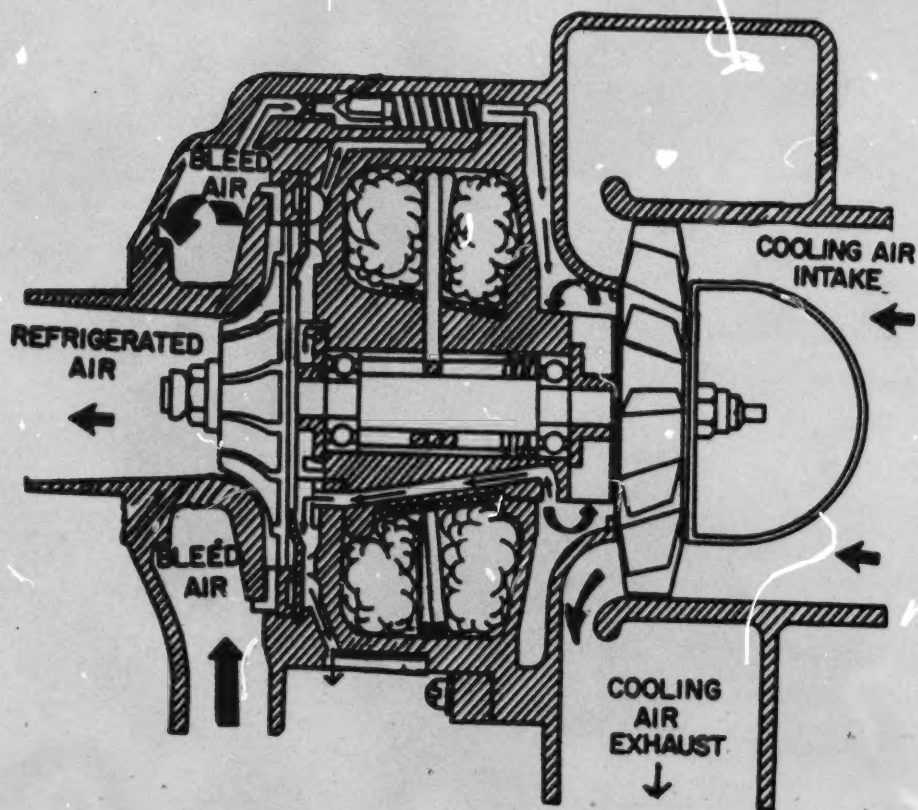


Figure 3. Turbine - Oil Pack Type.

2144

Answers to Frame 6: ✓ 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5.
✓ 6.

Frame 7

Now let's discuss the compressor type turbine. This type turbine is much the same as the last two with the exception that EBA is routed through the fan and turbine wheel. Consider figure 4 as we discuss the airflow.

Engine bleed air enters at the inlet port (a) and passes through the primary heat exchanger (b). The air then enters the compressor end of the turbine assembly (e) where the pressure is increased. The air then passes through the secondary heat exchanger (c) for a further reduction of temperature. Then, the air enters the turbine wheel where the air is cooled further by rapid expansion and then routed to the cooling air outlet (d).

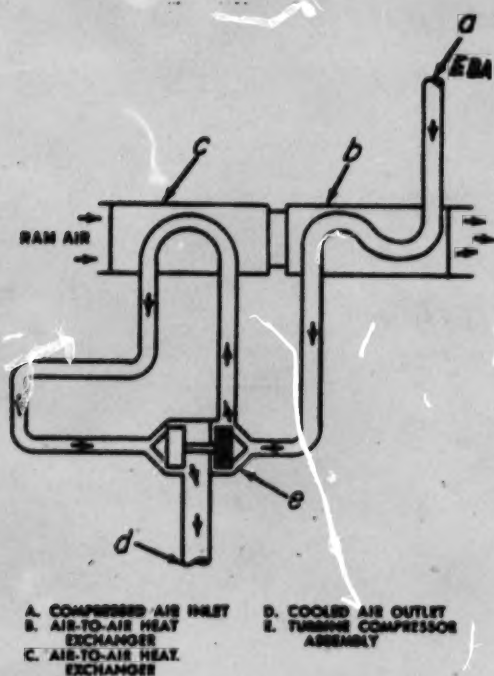


Figure 4.

Note: Check (✓) the following statements that are true.

- 1. Engine bleed air is routed to both the compressor and the turbine wheel in a compressor type turbine.
- 2. The compressor end of the turbine assembly compresses air.
- 3. The turbine wheel by rapid expansion cools the engine bleed air in a compressor type turbine.
- 4. Compressor type turbines are much the same as a sump type turbines.

Frame 8

The variable nozzle turbine is the only cooling turbine that maintains a constant speed. As you can see in figure 5 below, the wider open the nozzle blades (a) are the faster the turbine wheel will rotate. The further closed the nozzle blades are, the slower the turbine wheel will rotate. An actuator opens and closes the nozzle blades. In this way the turbine can be made to run at a constant speed of approximately 43,000 revolutions per minute (rpm). This allows a constant supply of refrigerated air to the cockpit.

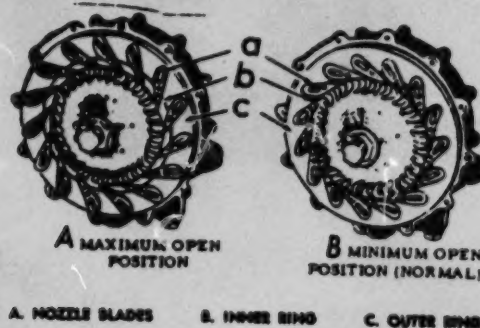


Figure 5.

Note: Check (✓) the statements that are true.

- 1. Closing the nozzle blades decreases the speed of the turbine wheel.
- 2. The variable nozzle turbine keeps a constant speed by changing the position of the nozzle blades.
- 3. Opening the nozzle blades decreases the speed of the turbine blades.
- 4. Keeping the turbine wheel at a constant speed maintains a steady supply of conditioned air to the cockpit.

////////

2146 Answers to Frame 8: ✓ 1. ✓ 2. 3. ✓ 4.

Frame 9

This completes the discussion on the major types of cooling turbines used in aircraft systems. Before we close there is one very important thing to remember—never overfill the turbine unit with oil. The bearings on an overfilled turbine unit seize faster than one with too little oil in it.

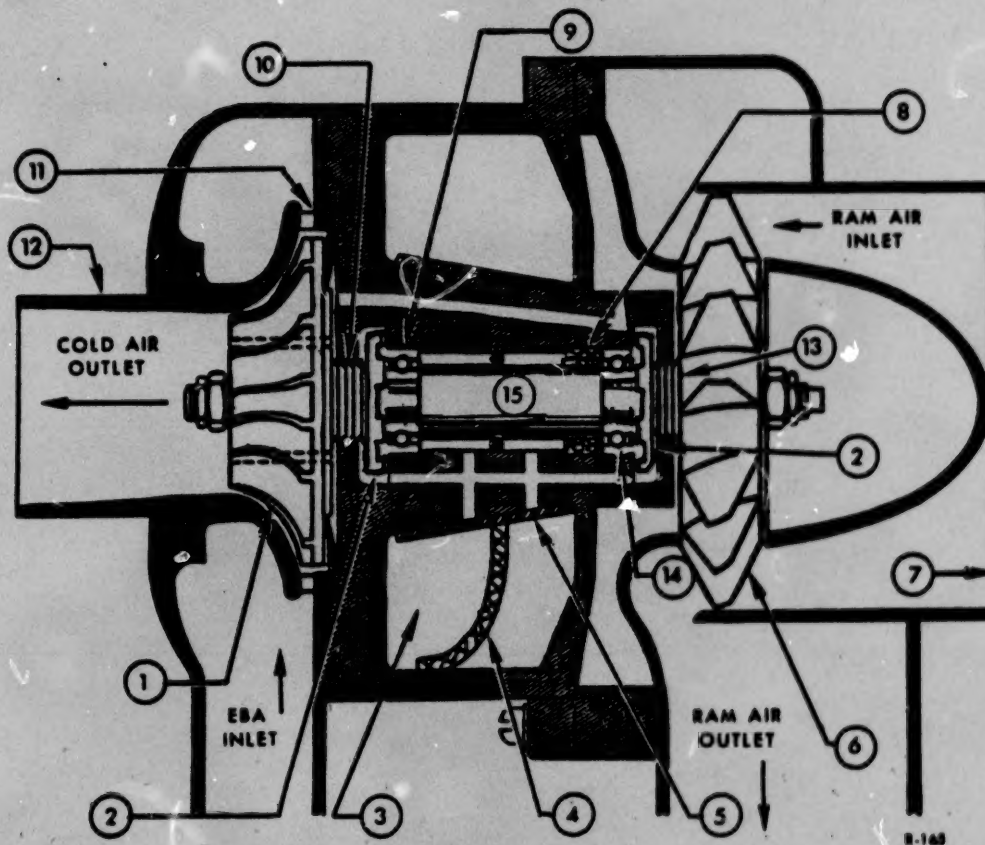
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No Response Required

305

Answer to Frame 9: None Required.

2147



- | | | |
|------------------------|--------------------------|--------------------------|
| ① <u>TURBINE WHEEL</u> | ⑥ <u>FAN</u> | ⑪ <u>NOZZLE RING</u> |
| ② <u>SLINGER RING</u> | ⑦ <u>RAM AIR INLET</u> | ⑫ <u>COLD AIR OUTLET</u> |
| ③ <u>OIL SUMP</u> | ⑧ <u>PRE-LOAD SPRING</u> | ⑬ <u>LABYRINTH SEAL</u> |
| ④ <u>WICK</u> | ⑨ <u>BEARING</u> | ⑭ <u>BEARING</u> |
| ⑤ <u>BLANKET</u> | ⑩ <u>LABYRINTH SEAL</u> | ⑮ <u>SHAFT</u> |



Technical Training

Aircraft Environmental Systems Mechanic

ADVANCED FIGHTER-BOMBER AIR SOURCE CONTROL SYSTEM

15 December 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in Course 3ABR42231. The text has been validated using 30 students from the subject course. All of the students achieved at least 90% of the objectives as stated. Average time for completion of the text is six hours.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each frame you are asked to complete a statement, select the true or false statement or match some statements. Read the material presented and make your response as directed. After you have responded, compare your response with the correct answer given on the even numbered page following each frame. If necessary, you may go back to check information previously given, but do not skip ahead. Foldouts number 1, 2, and 3 will be in the back of the text.

OBJECTIVES

After you complete this text, you will be able to:

1. Select statements that identify the function of the following components.
 - a. Engine bleed air check and shutoff valve.
 - b. Air conditioning system pressure regulator and shut-off valve.
 - c. Service air pressure regulator.
 - d. Hot air temperature control valve and sensor.
 - e. Cooling turbine inlet and bypass overtemperature switches.
 - f. Emergency ram air actuator and door.
2. Recall the purpose of the service air system.
3. Trace the electrical circuits for control of the engine bleed air check and shutoff valves, hot air temperature control valve, pressure regulator.

EQUIPMENT

Make sure you have colored pencils available for tracing circuits in your diagram.

Supersedes ST 3ABR42231-PT-308, 21 August 1973, that can be used until existing stocks are exhausted.

OPR: TAS

DISTRIBUTION: X

TAS - 500; TTVGC - 2

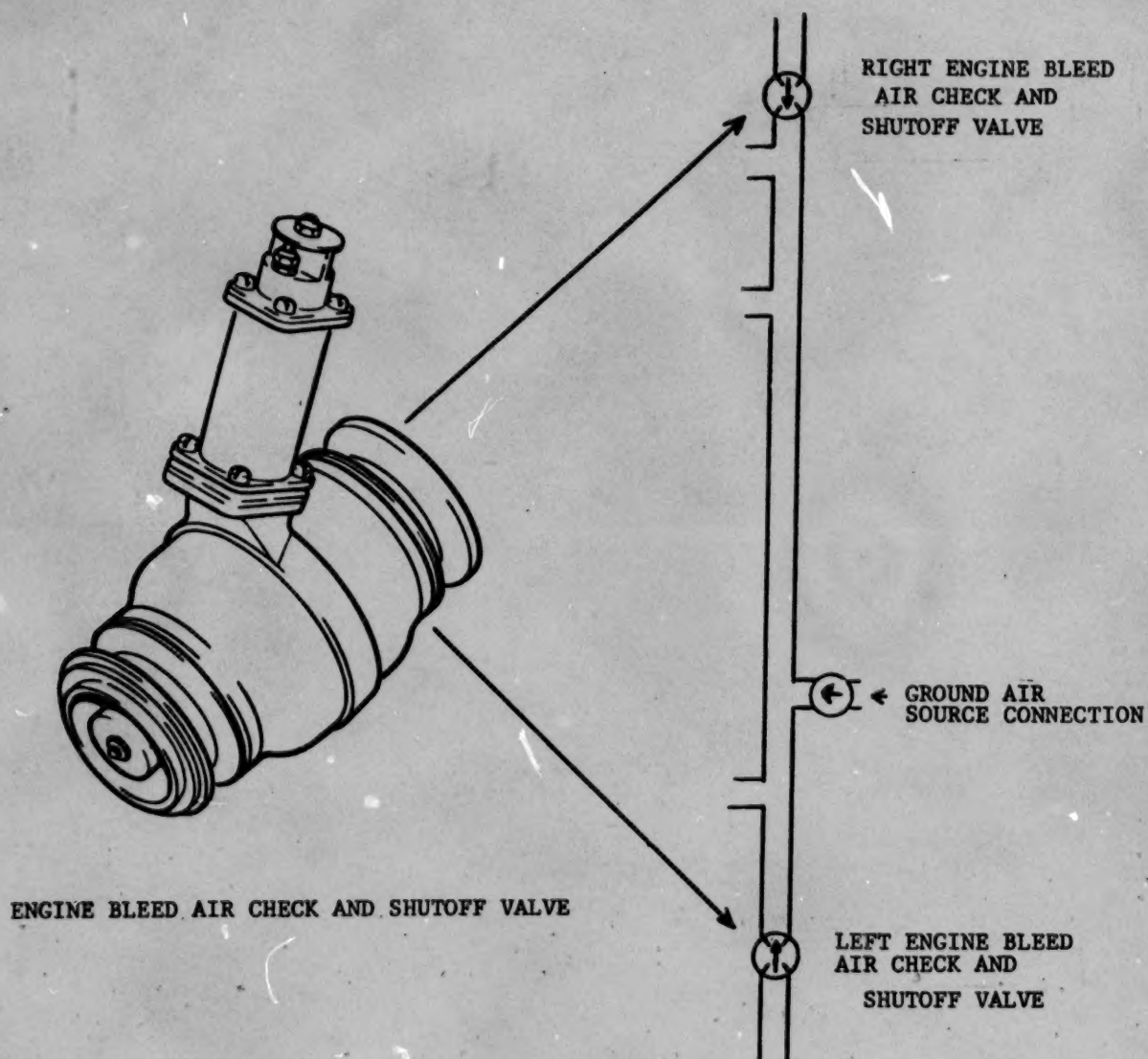


Figure 1.

2151

Correct Responses to Frame 2: 1. closed, 2. open, 3. check, shutoff, 4. check, shutoff, 5. solenoid

Frame 3

Figure 2 shows two views of an engine bleed air check and shutoff valve. The top view shows the solenoid energized when the engine is not operating. Notice the springs that hold both the shutoff and the check poppets in the closed positions, when the engine is not operating.

The lower view shows the solenoid energized when the engine is operating. The engine bleed air will push the check part of the valve open. Air can then flow through the passage to the solenoid. From the solenoid air can flow through a passage to the back side of the shutoff poppet. The pressure will build up in back of the poppet and will hold the poppet in the closed position.

In the following statements, fill in the missing information in the spaces provided.

1. If there is a loss of 28V DC electrical power, the engine bleed air check and shutoff valves will _____ (open/close).
2. With no air in the system, the poppets are held closed by _____.
3. When the engine is operating and the solenoid is energized, the check poppet will be _____ and the shutoff poppet will be _____.

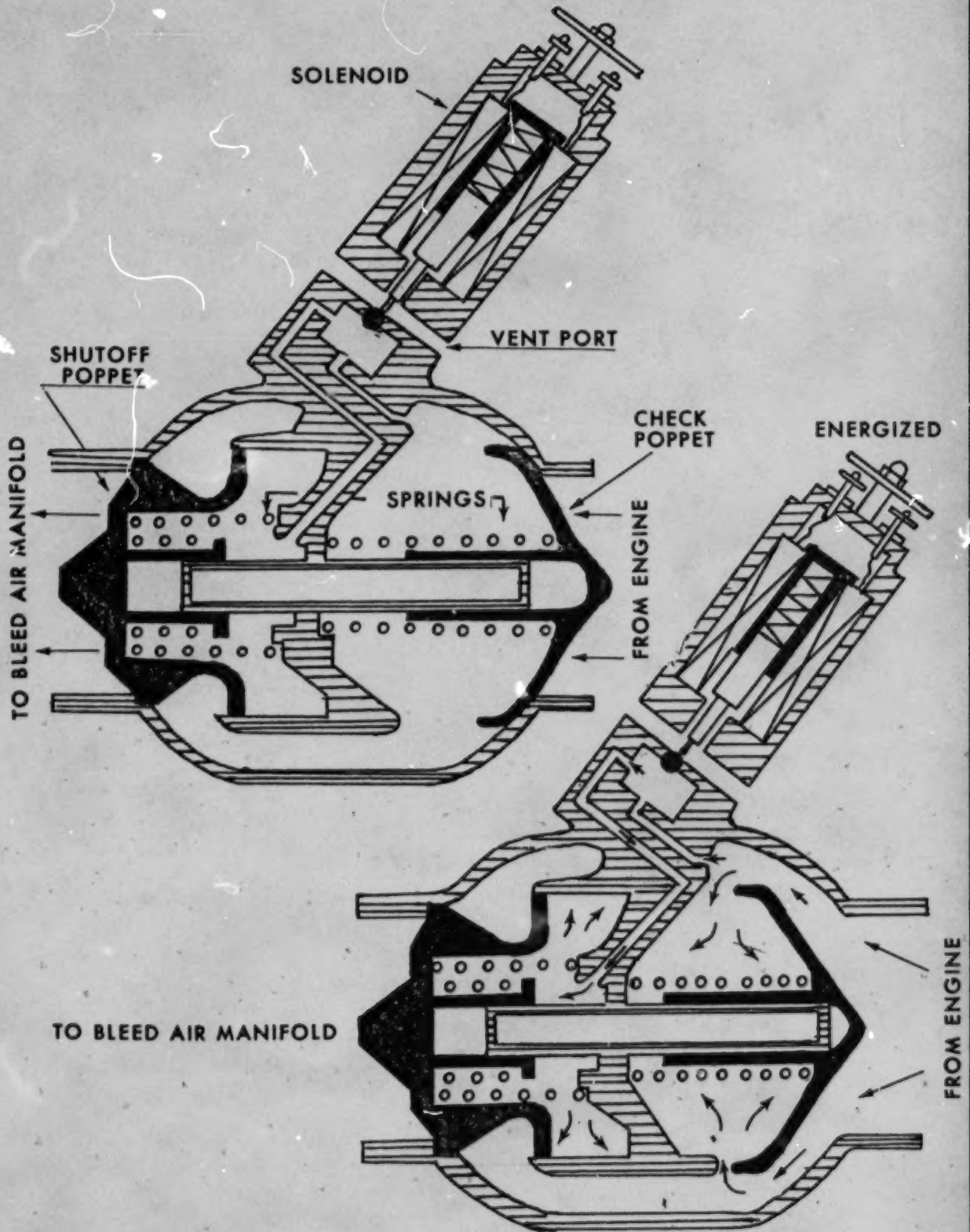


Figure 2.

1155
Correct Responses to Frame 3: 1. open, 2. springs, 3. open,
closed

Frame 4

The top view in figure 3 shows the solenoid deenergized. With the engine running, air will push the check poppet open. With the solenoid deenergized the air can not flow through the passage to the back side of the shutoff poppet. The air on the back side of the shutoff poppet can bleed out to the atmosphere through the vent on the solenoid. This air, in turn, goes to the outside of the shutoff poppet, overcomes the spring tension and will push the poppet open. Air can then flow through the bleed air manifold.

The lower view shows the solenoid energized, when the engine is not operating. The bleed air manifold is pressurized from the other engine or a ground air cart. The air in the bleed air manifold overcomes the spring tension and opens the shutoff poppet, but can not open the check poppet. This will stop the loss of bleed air to the engine that is not operating.

In the following statements, fill in the missing information in the spaces provided.

1. When the solenoid is deenergized, the vent port is _____.
2. When the solenoid is deenergized, the shutoff poppet is moved open by _____.
3. When the engine is not operating, a reverse flow of air is prevented by the _____.

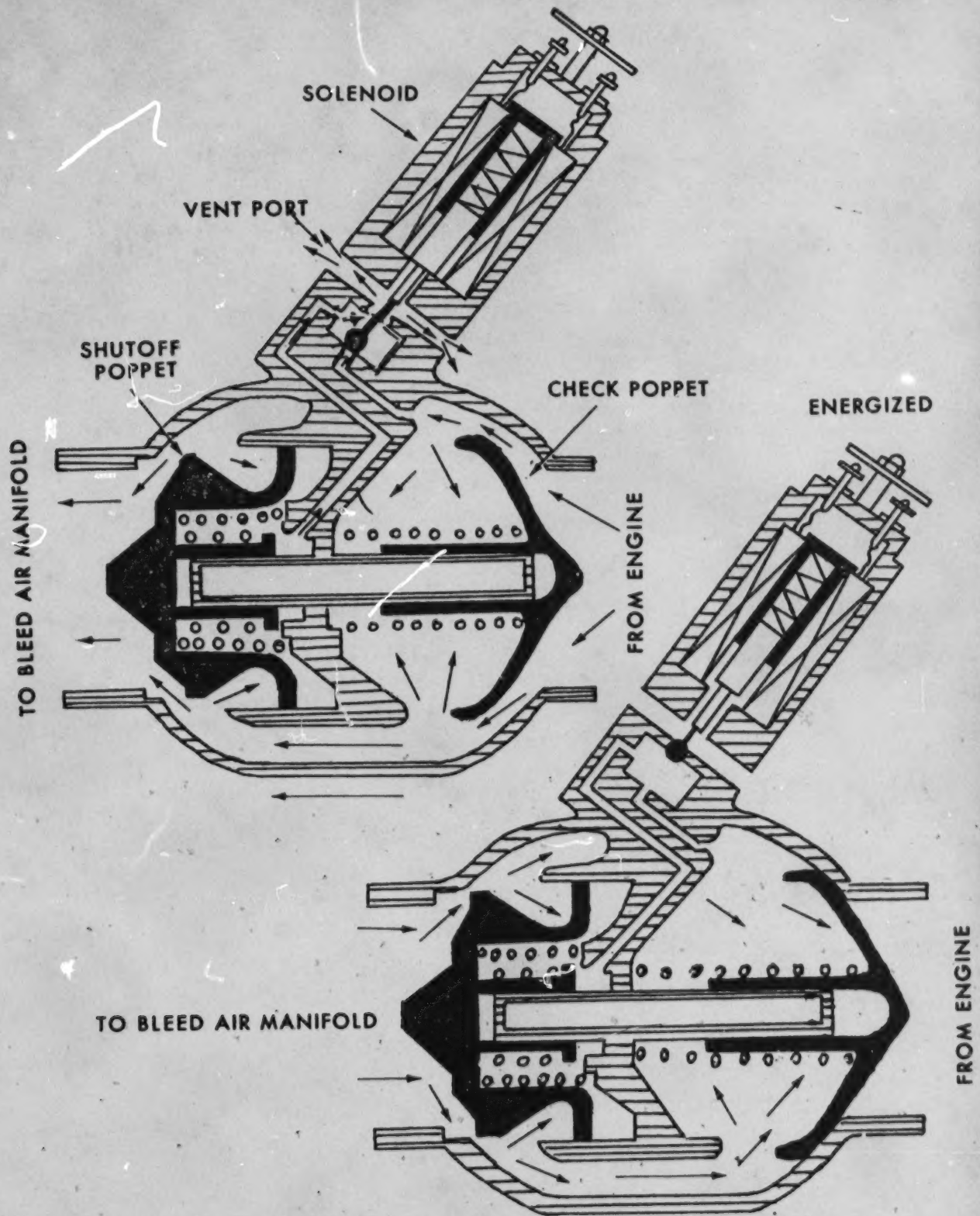


Figure 3.

Correct Responses to Frame 4: 1. open, 2. air, pressure, 3. check, poppet

Frame 5

In figures 2 and 3 we have seen how the engine bleed air check and shutoff valves operate. We will now learn how the engine bleed air check and shutoff valve solenoids are controlled. Each engine has a valve and a solenoid. Keep in mind that, when the solenoids are deenergized and the engines are operating, the valves are open. When the solenoids are energized and the engines are operating, the valves are closed. The engine bleed air check and shutoff valve solenoids are controlled by: (1) the air source switch, and (2) the engine start relays.

The air source switch (figure 4) is a wafer switch. This means there are six switches put together on one selector. When the selector is moved all six switches (wafers) move at the same time. The air source switch is used to choose the source of air for air conditioning. The switch can be moved to five positions: OFF, LEFT, BOTH, RIGHT, and RAM.

When in the OFF position both the left and right engine bleed air check and shutoff valve solenoids are energized. Keep in mind that the energized solenoids will cause the valves to close. With the valves closed air cannot flow from the right or left engines for air conditioning. The LEFT, BOTH and RIGHT switch positions just control the valve or valves from which bleed air is taken. That is, with the switch in the LEFT position and both engines are operating, air flow is just from the left engine. When in the BOTH position air flows in from both engines. In the RIGHT position air flows in from the right engine.

In the following statements, fill in the missing information in the spaces provided.

1. The positions of the air source switch are _____.
2. The left engine bleed air check and shutoff valve will close when the air source switch is put in _____ or _____.
3. The air source switch is found on the _____ panel.
4. When the air source switch is put in BOTH, the left and right engine bleed air check and shutoff valve solenoid will be _____.
5. With the air source switch in the RIGHT position, the air will be received from the _____ engine.

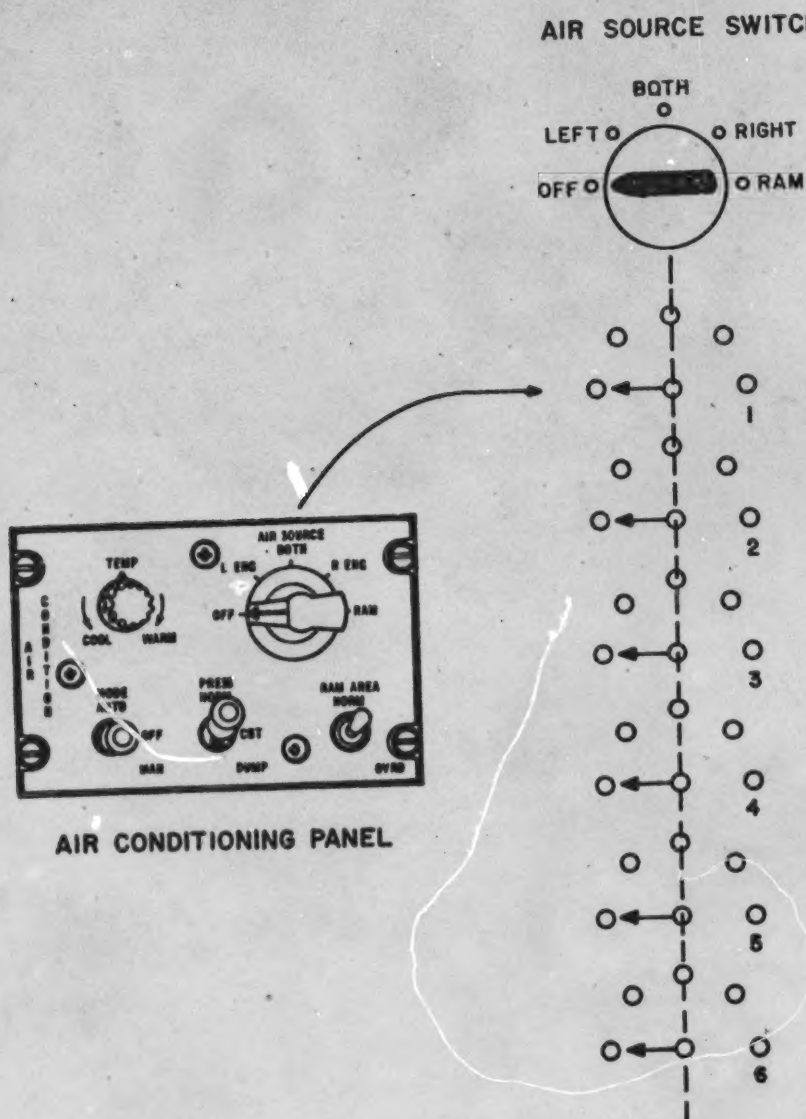


Figure 4.

2159

Correct Responses to Frame 5: 1. OFF, LEFT, BOTH, RIGHT, RAM,
2. right, ram, 3. air conditioning, 4. deenergized, 5. right

Note: Foldout number 1 will be used with Frames 6 through 8.

Frame 6

Use foldout number 1. The wiring diagram in foldout number 1 shows the electrical circuits that control the engine bleed air check and shutoff valves. As was stated, the engine bleed air check and shutoff valves are controlled by the air source switch or by the engine start relays. We are still just concerned with the air source switch.

Locate the following parts on the wiring diagram and check off each part (✓).

- Left engine bleed air circuit breaker (CB-6).-----.
- Right engine bleed air circuit breaker (CB-7).-----.
- Air source switch (only two wafers are shown).-----.
- Right engine start relay.-----.
- Left engine start relay.-----.
- Right engine bleed air check and shutoff valve solenoid.-----.
- Left engine bleed air check and shutoff valve solenoid.-----.

Use a blue pencil to trace the following circuits and check (✓) each step you complete.

Trace the circuit with the air source switch in the left position.

1. Start at CB-7 (right engine bleed air) and trace the wire to pin T on the air conditioning panel.-----.
2. From pin T, trace the wire to the air source switch center terminal or wafer number 1.-----.
3. Now draw the switch in the left position and trace the wire to pin S on the air conditioning panel.-----.
4. Notice that with the air source in OFF or LEFT, current will go to pin S.-----.
5. From pin S, trace the wire to pin B-2 of the left engine start relay. The left engine start relay is not energized.-----.

6. Trace the circuit across the relay contact to pin B-3.-----.
7. From B-3 trace to pin B-1 of the right engine bleed air check and shutoff valve solenoid.-----.

What has happened? We put the air source switch in the left position and it energized the right engine bleed air check and shutoff valve. Keep in mind, the engine bleed air check and shutoff valve is energized closed. So, if we choose left on the air source switch, we want the left engine bleed air check and shutoff valve to be deenergized (open) and the right valve energized (closed). Thus, we get air flow from the left engine.

Use a red pencil to trace the following circuits and check (✓) each section you complete.

Trace the circuit with the air source switch in the right position.

1. Start at CB-6 (left engine bleed air) and trace the circuit to pin O on the air conditioning panel.-----.
2. From pin O, trace the wire to the center terminal wafer number 2 on the air source switch.-----.
3. Now draw the switch to the right position and trace the wire to pin R on the air conditioning panel. Notice that with the air source switch in the OFF or RIGHT position current will flow to pin R on the air conditioning panel.-----.
4. Trace the circuit from pin R to B-2 on the right engine start relay. The right engine start relay is not energized.-----.
5. Trace across the relay contact to pin B-3 and to the left engine bleed air check and shutoff valve solenoid.-----.

We chose the right position on the air source switch and energized the left engine bleed air check and shutoff valve solenoid. The solenoid will close and leave the right engine bleed air check and shutoff valves deenergized. We now have air flow from the right engine.

2/61

Correct Responses to Frame 6: Tracing of circuits on foldout number 1.

Frame 7

Look at foldout number 1. The second means of controlling the bleed air check and shutoff valves is by the start relays. The right engine start relay is energized just while the right engine is being started. The left engine start relay is energized just when the left engine is to be started. The left engine is started with air supplied from a ground air cart. After the left engine is operating, the ground air cart is removed. Airflow is from the left engine. The left engine bleed air check and shutoff valve must be open. This is how the engine start relays control the action.

In the following statement, fill in the missing information in the space provided.

1. The right engine start relay is energized when starting the _____ engine.

Look at foldout number 1. You have traced the circuits with the air source switch in the left and right positions. Now put the air source switch to the OFF position. Trace the circuit to both bleed air check and shutoff valves. Both are energized. During a left engine start, the left engine start relay is energized. This will pull the contact down and break the circuit to the right engine bleed air check and shutoff valve solenoid. When the left engine is operating, the engine start relay deenergizes. This will let current flow to the right bleed air check and shutoff valve. Now that the left engine is operating, the ground air cart can be disconnected. When the right engine starts, the right engine start relay deenergizes and current will flow to the left engine bleed air check and shutoff valve solenoid and close it. With the air source switch in BOTH or RAM, both engine bleed air check and shutoff valves will be deenergized. The air source switch turns air conditioning on or off by controlling the bleed air check and shutoff valves.

In the following statement, fill in the missing information in the space provided.

1. The left engine start relay controls the _____ engine bleed air check and shutoff valve.

2163

Correct response to Frame 7: 1. right
Correct Response to Frame 8: 1. right

Note: Foldout number 2 will be used with Frames 9 through 12.

Frame 9

Look at foldout number 2. The next system is the service air system. The service air system gives cooled air to control various valves and to operate some auxiliary systems.

The first part in the service air system is the service air pressure regulating valve. Look at the lower section of foldout number 2. This valve is two (2) valves in one. The two parts are the primary regulator and secondary regulator. The primary regulator controls air flow to a pressure of 55 psi. The primary regulator has a red indicator that moves up when the pressure is 60 to 66 psi. When the red indicator moves up, the secondary regulator will control air pressure. The secondary regulator controls air pressure to 73 psi. When the red indicator sticks out the service air pressure regulating valve should be removed and a new valve put in.

In the following statement, fill in the missing information in the space provided.

1. The service air is _____ PSI.

Look at foldout number 2. The next part in the service air pressure system is a check valve. The check valve stops the reverse of air flow when the engines are not operating. From the check valve, service air goes to the first stage of cooling, then to the air-to-air heat exchanger. Cooling ram air is passed through a duct and sent across the heat exchanger core. Heat from the service air is transferred through the thin walls and fins of the cores. Cooling ram air over the core will drop the temperature of the service air.

NO RESPONSE REQUIRED

2165

Correct Response to Frame 9: 1. 55

Correct Response to Frame 10: None Required

Frame 11

Look at foldout number 2. The air-to-water heat exchanger is the second stage of cooling for service air. During subsonic and most supersonic flight, the cooling ram air temperature is too high to cool the service air using just the air-to-air heat exchanger. When this happens, the air-to-water heat exchanger will cool service air to the temperature of boiling water. As the hot service air goes through the cores, heat is transferred to the water. If the service air temperature that goes in the air-to-water heat exchanger is below the boiling point of water, little or no heat transfer will take place. At an altitude above sea level, the reduced ambient air pressure will lower the boiling point of water. The temperature of the service air can then be reduced as much as 100°F below the boiling temperature of water (212°) at sea level.

NO RESPONSE REQUIRED

Look at foldout number 2. The service air-to-air heat exchanger is the final cooling stage for the service air. This heat exchanger is made of two aluminum ducts, one inside the other. Cold air from the turbine flows through the inner duct. Service air flows through the outer duct and is cooled by this air. The surface between the ducts is finned for a better transfer of heat. Cool service air from the service air-to-air heat exchanger is routed to each air system part.

Trace service air through all the service air system parts that has been covered. Look at foldout number 2. Trace the flow of air from both engine bleed air check and shutoff valves to the service air tap-off. After flowing through the service air pressure regulating valve, service air flows through the check valve and to the air-to-air heat exchanger. From there it goes to the air-to-water heat exchanger and to the service air-to-air heat exchanger. Then it's directed to the points of use.

In the following statement, fill in the missing information in the spaces provided.

1. The final stage of cooling in the service air system is done by the _____.

2167

Correct Response to Frame 11: None Required

Correct Responses to Frame 12: 1. air-to-air heat exchanger

Frame 13

The pressure regulating and shutoff valve is a two purpose valve. It will regulate or turn off bleed air. The regulating part of the valve keeps engine bleed air to a pressure of 165 psi. Look at figure 5. The shaded ducts downstream of the pressure regulating and shutoff valve show regulated bleed air. Bleed air pressure to go to the valve may be as high as 500 psi. The shutoff part of the valve shuts off engine bleed air. The pressure regulating and shutoff valve is electrically controlled, pneumatically operated. Applying 28V DC power to the valve solenoid will cause the valve to close.

In the following conditions 28V DC will be applied to the pressure regulating and shutoff valve solenoid:

1. In the engine start cycle when the left or right engine start relay is energized. This is to stop a loss of starter air through the cooling components.
2. When the cooling turbine inlet temperature is more than 350°F.
3. When the cooling turbine bypass temperature is more than 165°F.
4. When the air source switch is moved to RAM.

The pressure regulating and shutoff valve has a RED overpressure indicator. If the downstream pressure should rise more than a set valve, the plunger in the red indicator will move to the out position. This will show that pressure limit has been exceeded.

If the red indicator is found to be out, the cold air ducting downstream of the valve shall be visually inspected for damage, followed by regulated pressure check. The red indicator can be reset if the inspection and regulation check are good.

In the following statements, fill in the missing information in the spaces provided.

1. When starting the left or right engine the pressure regulating and shutoff valve will _____.
2. The pressure regulator and shutoff valve can be closed by _____ (energizing/deenergizing) a solenoid.
3. When the air source switch is moved to RAM the pressure regulating and shutoff valve will _____.

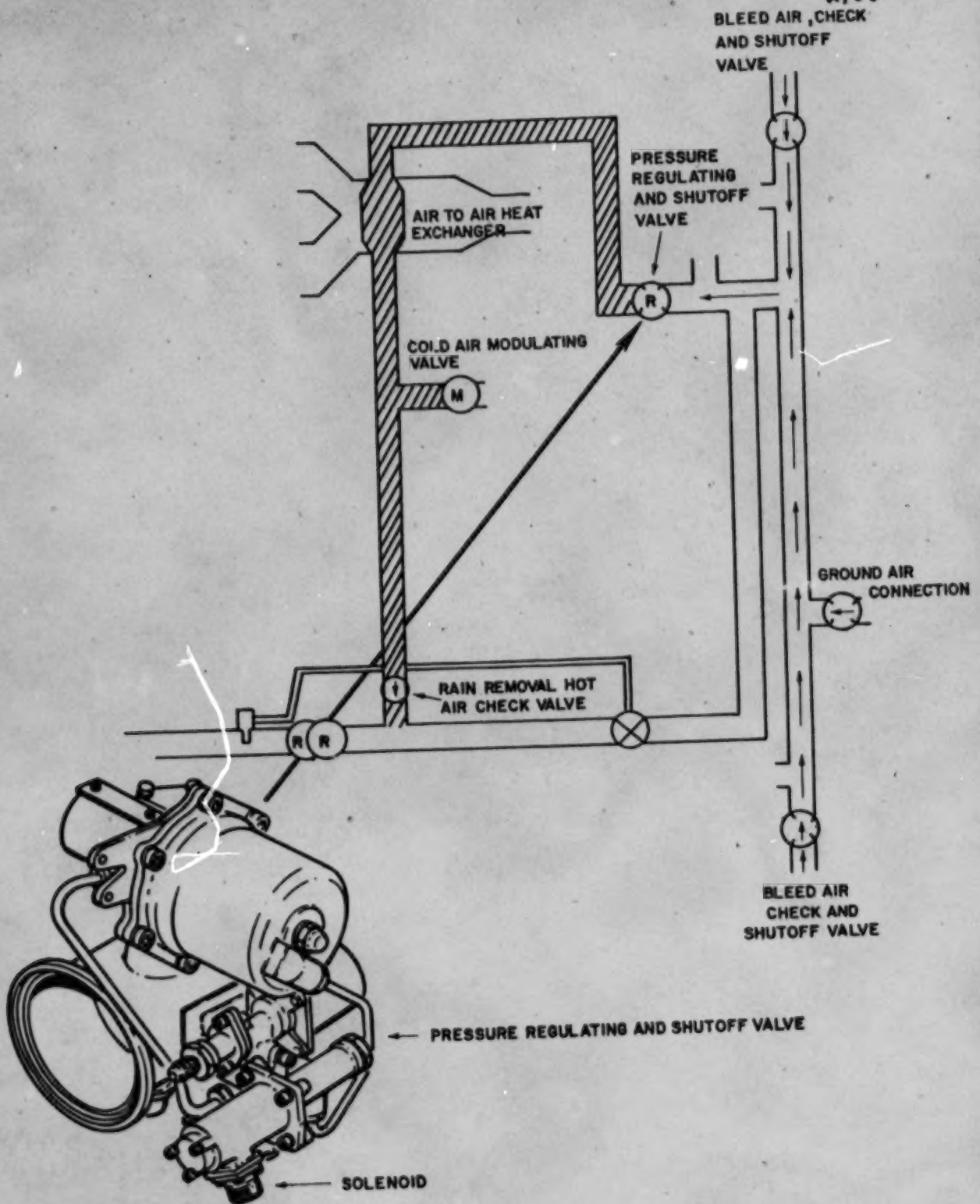


Figure 5.

Correct Responses to Frame 13: 1. close, 2. energizing, 3. close

Frame 14

You now know that a cooling turbine inlet overtemperature condition will close the pressure regulating and shutoff valve. The cooling turbine overtemperature thermostatic switch protects the cooling turbine from overheating. Look at figure 6. The cooling turbine overtemperature thermostatic switch is placed in the bleed air duct to the turbine wheel. If the turbine air duct temperature should reach 350°F, the switch will close the pressure regulating and shutoff valve. This will cause the valve to shut off the engine bleed air to the turbine. The three conditions that could cause a turbine overheat are:

1. The air-to-air heat exchanger ram air duct is blocked.
2. The air-to-water heat exchanger could boil dry. This would cause an overtemperature condition at high engine settings.
3. Failure of the bleed air ejector valve (this will be covered in a later lesson).

A cooling turbine bypass overtemperature condition will close the pressure regulating and shutoff valve. The turbine bypass valve is open in certain conditions that will be covered later. The cooling turbine bypass overtemperature thermostatic switch will close the pressure regulating and shutoff valve if the turbine bypass temperature is more than 165°F. Look at figure 6. The cooling turbine bypass overtemperature thermostatic switch is in the turbine bypass duct just upstream of the turbine bypass valve.

In the following statement, fill in the missing information in the space provided.

1. The pressure regulating and shutoff valve will not open. This could be caused by a _____ (open/short) in either the cooling turbine inlet overtemperature switch or the cooling turbine bypass overtemperature switch.

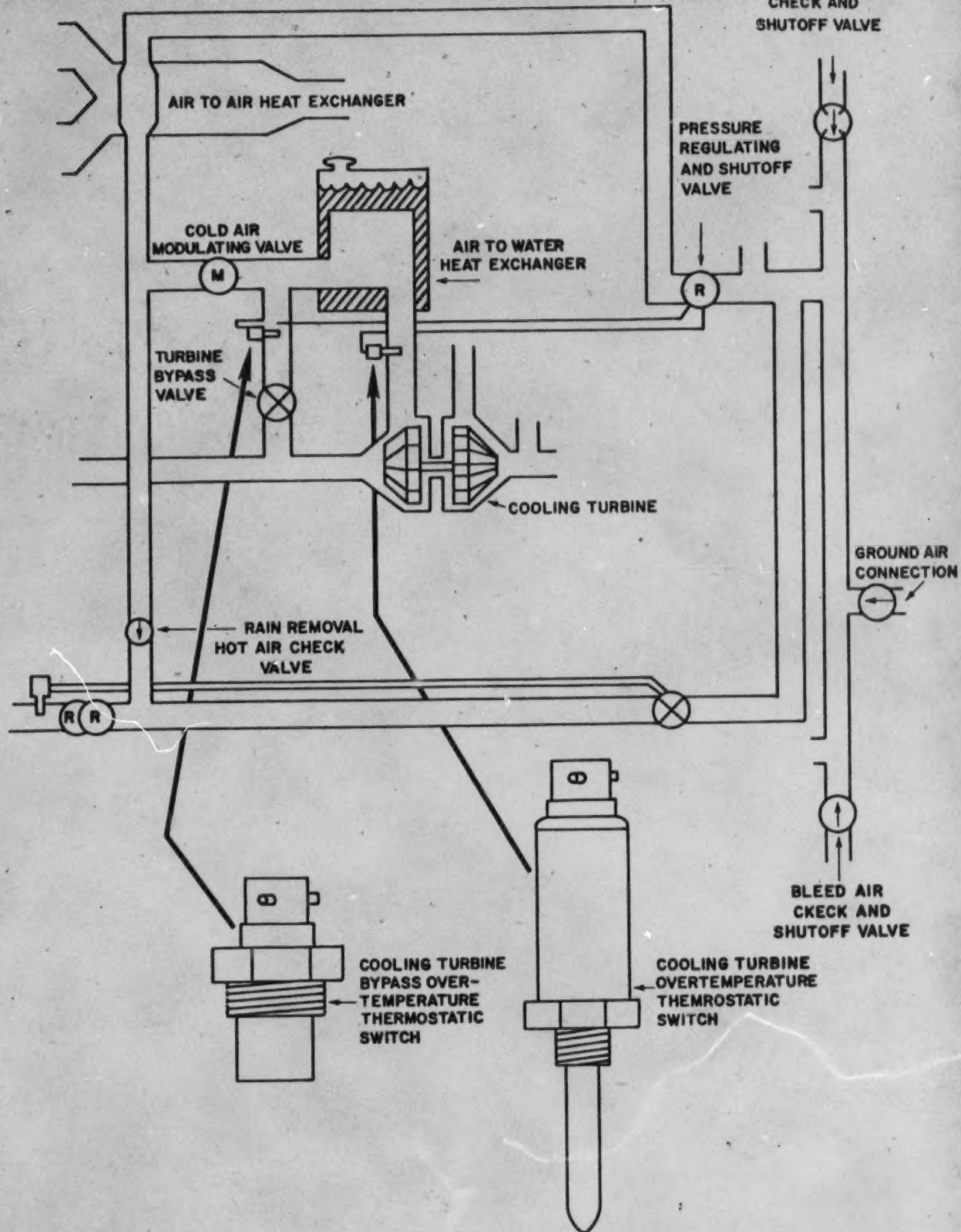


Figure 6.

2171
Correct Response to Frame 14: 1. short

Frame 15

Look at the wiring schematic to see how the pressure regulating and shutoff valve solenoid is energized. Use foldout number 3. Find the following parts on the wiring schematic and check off each part (✓).

1. Circuit breaker 3 (28V DC).-----.
2. Air conditioning control panel.-----.
3. Air source switch.-----.
4. Right engine start relay.-----.
5. Left engine start relay.-----.
6. Pressure regulating and shutoff valve.-----.
7. Cooling turbine overtemperature thermostwitch.-----.
8. Cooling turbine bypass overtemperature
thermostwitch.-----.

Use a blue pencil to trace the following circuits and check (✓) each step you complete.

1. Trace 28V DC from CB3 along wire H502A22 to pin
P on the air conditioning control panel.-----.
2. From pin P trace the 28V DC to the center terminal
of the air source switch.-----.
3. The pressure regulator and shutoff valve (SOV) is
energized during emergency ram operation. Place
the air source switch in the RAM position.-----.
4. Current then flows to pin N and along wire H514D22
from terminal 1 on TB3.-----.
5. Trace wire H514A22 from terminal 1 on TB3 to pin
4 on the pressure regulating and shutoff valve.-----.
6. From pin 4, 28V DC energizes the solenoid and
goes to pin 1 on the ground.-----.

When the air source switch is in the RAM position the pressure regulating and shutoff valve solenoid is energized closing the valve.

Trace the circuits to the cooling turbine overtemperature thermostatic switch and cooling turbine bypass overtemperature thermostatic switch. Check each step you complete. (✓).

1. Start on CB3 (28V DC) with a red pencil and trace wire H501J22 to terminal A2 on the left engine start relay. From terminal A2 trace wire 39B22 to terminal A2 on the right engine start relay.-----.
2. Trace wire 39C22 from terminal A2 to C2 on the same relay and along wire 39D22 to terminal C2 on the left engine start relay.-----.
3. Trace wire H502A22 from C2 to terminal 3 on TB3.-----.
4. At terminal 3 on TB3 the 28V DC goes two different ways.-----.
5. Trace wire H502L22 to pin 2 on the cooling turbine overtemperature thermostatic switch on to the contacts.-----.
6. This switch is normally open so this is as far as we can go. Let us back up to terminal 3 on TB3 and trace wire H502K22 to pin 4 on the cooling turbine bypass overtemperature thermostatic switch. Again we come to a normally open switch. Now we have the power potential at both of the overtemperature switches.-----.
7. Let us say the turbine inlet temperature is more than 350°F. With this condition the normally open cooling turbine overtemperature thermostatic switch will close and let the 28V DC flow through the switch and out pin 1.-----.
8. From pin 1 current flows through wire H514C22 to terminal 2 on TB3.-----.
9. From terminal 2, trace wire H514G22 to terminal 1, then out wire H514A22 to pin 4 on the pressure regulating and shutoff valve.-----.

28V DC energizes the solenoid and will close the valve. This shuts off air flow to the cooling turbine and will let it cool off.

If the cooling turbine bypass temperature is more than 165°F the cooling turbine bypass switch would close. This would send 28V DC to the pressure regulating and shutoff valve solenoid on the same route as the cooling turbine inlet or turbine bypass duct. This circuit will close the pressure regulating and shutoff valve. Let us trace the circuit to the pressure regulating and shutoff valve during engine start.

We traced power from circuit breaker CB3 to C2 on the left and right engine start relays. The power potential at C2 will be used to close the pressure regulating and shutoff valves during engine start.

Now to start the left engine. The left engine start relay is energized during engine start.

Use an orange pencil to trace the following circuits and check (✓) each one you complete.

1. Trace the left engine start relay to the lower contact.-----.
2. From C1 the current flows through wire H514B22 to terminal 1 on TB3.-----.
3. From terminal 1 trace wire H514A22 to pin 4 on the pressure regulator and shutoff valve.-----.
4. From pin 4, power energizes the pressure regulator and shutoff valve solenoid, closing the valve.-----.

When the left engine is operating the left engine start relay deenergizes and breaks the circuit to the pressure regulator and shutoff valve reopening it.

Now to start the right engine. Trace the circuit with a brown pencil and check (✓) off each one you complete. The right engine start relay energizes during right engine start, moving the relay switch to the lower contact.

1. Trace from C1 on wire 33A22 to terminal C1 on the left engine start relay.-----.
2. From terminal C1 the current flows the same route to the pressure regulator and shutoff valve as it did during left engine start.-----.

After the right engine is operating, the right engine start relay deenergizes. This breaks the circuit to the pressure regulator and shutoff valve and again it opens. You have now seen the four different ways to close the pressure regulator and shutoff valve.

1. Left or right engine start.
2. Cooling turbine inlet overtemperature.
3. Cooling turbine bypass overtemperature.
4. By selecting ram air.

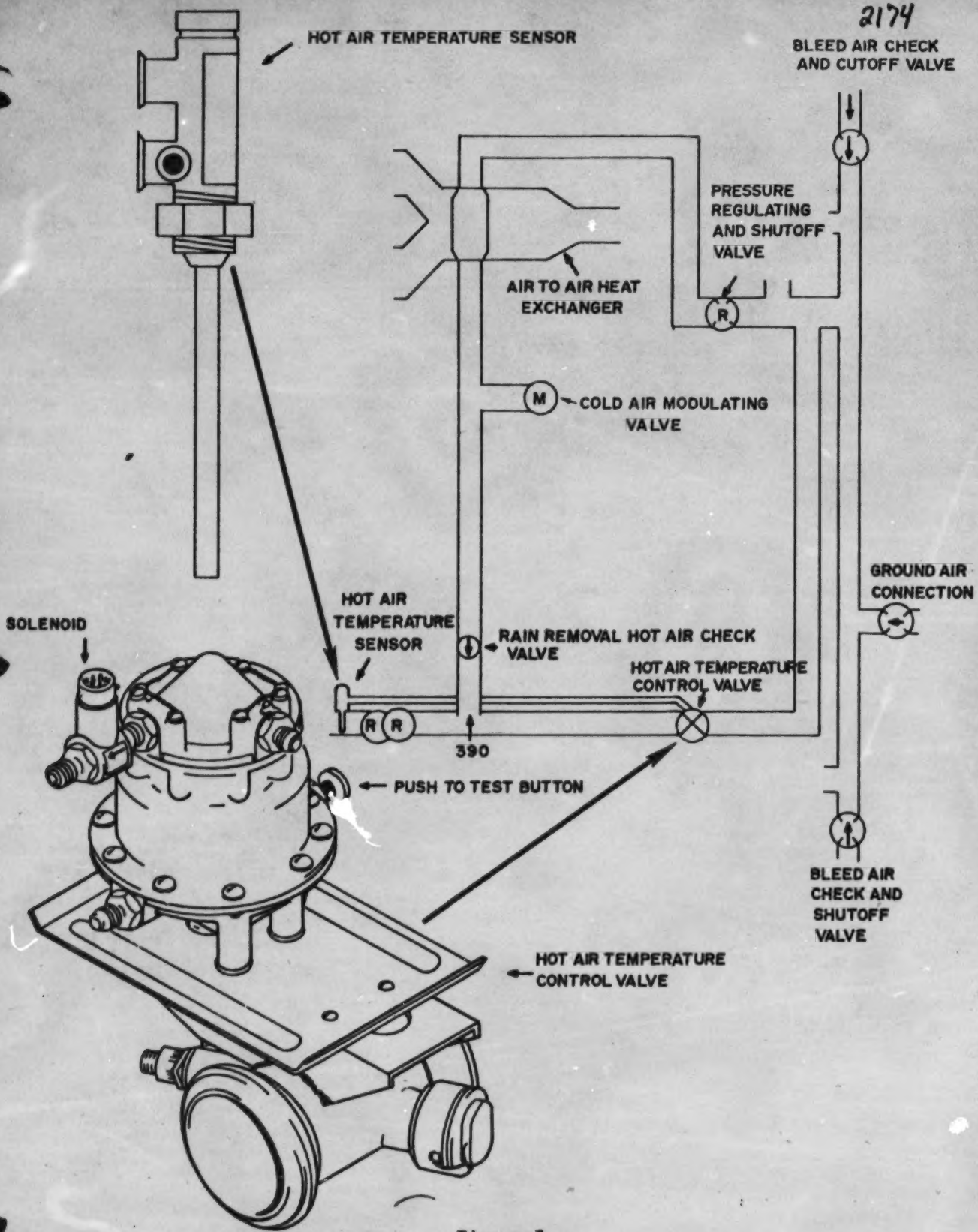


Figure 7.

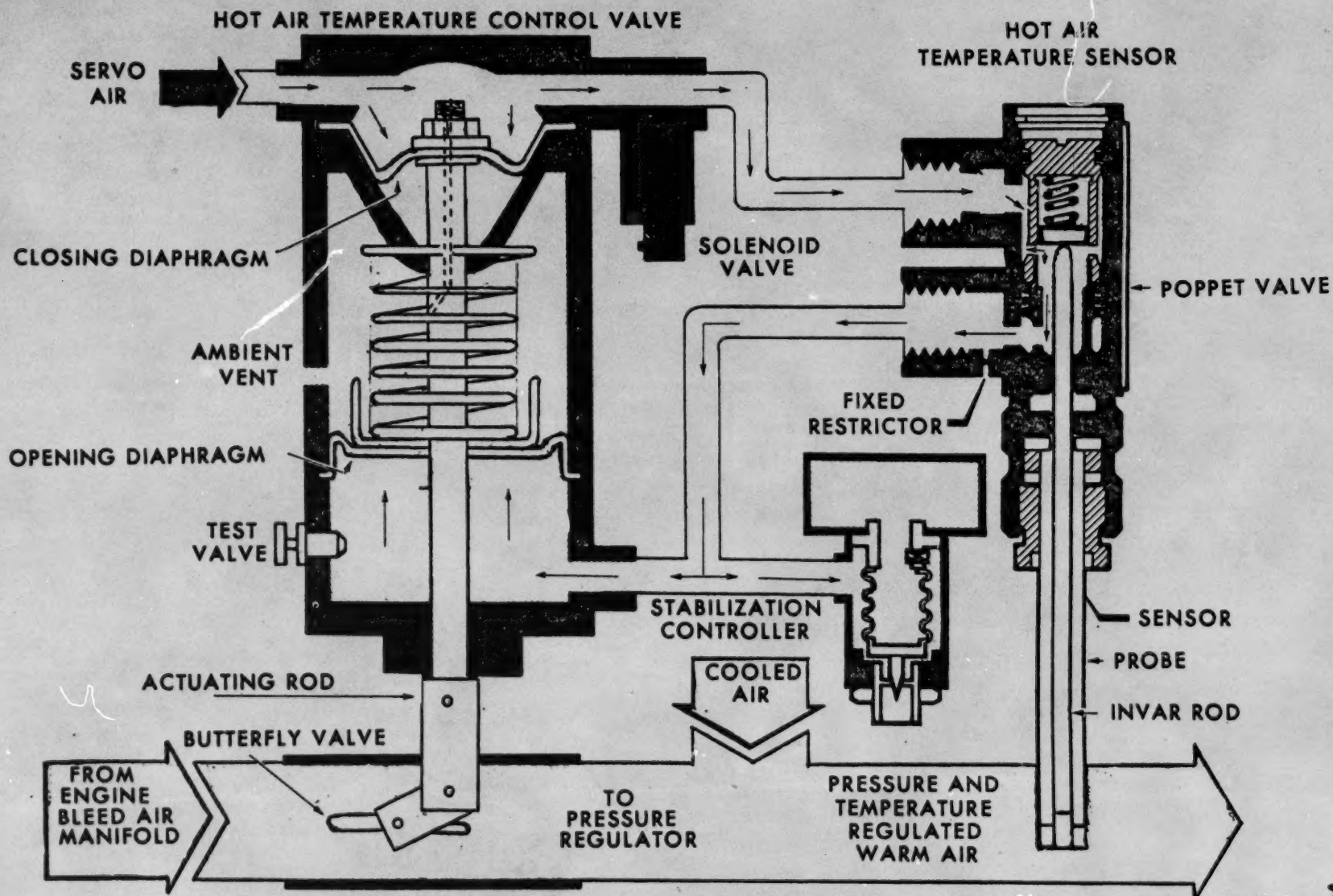
Frame 16

Next we will cover the hot air temperature control valve, the hot air temperature sensor, and the stabilization controller. These parts are in the hot air system. The hot air system sends conditioned regulated air to the low limit temperature control valve, the hot modulating valve, and the windshield clearing system. The hot air temperature control valve and sensor control bleed air temperature to 390°F. This is done by controlling the amount of bleed air that is mixed with partially conditioned air. The mix is to keep the hot air system at 390°F. Bleed air tapped off prior to the pressure regulator and shutoff valve goes to the hot temperature control valve. The hot air temperature control valve and the hot air temperature sensor control the amount of bleed air that is mixed with the partially cooled air to maintain 390°F.

Figure 7 shows the hot air temperature control valve. The hot air temperature control valve is a pneumatically actuated valve. Servo air from the service air system is used to move the valve. The hot air temperature control valve has a solenoid that is energized just for engine start. When the solenoid is energized (for engine start) the hot air temperature control valve will close. The hot air temperature control valve has a self-test feature. Notice the push to test button in figure 7. When the button is pushed, the valve will go to the closed position. The push to test feature is to let maintenance personnel (you) check the valve for good operation. The hot air temperature sensor is an air sensor. It controls the flow of service air to the hot air temperature control valve by sensing the changes in duct temperature. The sensor is made of a stainless steel probe, an invar rod, and a poppet valve. An invar rod is a type of rod that will not change length if there is a change in temperature. The stainless steel probe sticks out in the air duct. As the temperature around the probe gets to be more than 390°F the probe will expand. The invar rod will then transmit this motion to the poppet valve and cause it to move down. As the poppet valve moves down it slows the flow of air to the hot air temperature control valve opening diaphragm. This will cause the hot air temperature control valve to start closing.

The stabilization controller keeps the hot air temperature control valve from overreacting to a change in servo air pressure. Keep in mind, servo air pressure to the hot air temperature control valve is controlled by the hot air temperature sensor.

Look at an internal view of the hot air temperature control valve, hot air temperature sensor, and stabilization controller (figure 8).



**HOT AIR TEMPERATURE CONTROL VALVE, AND
SENSOR**

Figure 8.

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Correct Responses to Frame 15: Tracing of circuits on foldout number 3.

Frame 16 (Cont'd)

In the following statements, fill in the missing information in the spaces provided.

1. The hot air temperature sensor is a _____ thermostat.
2. If the air temperature at the hot air temperature sensor is more than 390°F, the hot air temperature control valve will _____.
3. Air temperature at the hot air temperature sensor is maintained at 390°F by controlling the flow of _____ air.
4. The hot air temperature sensor controls the _____ valve.
5. The purpose of the solenoid on the hot air temperature control valve is to _____ (open/close) the valve during the engine starts.

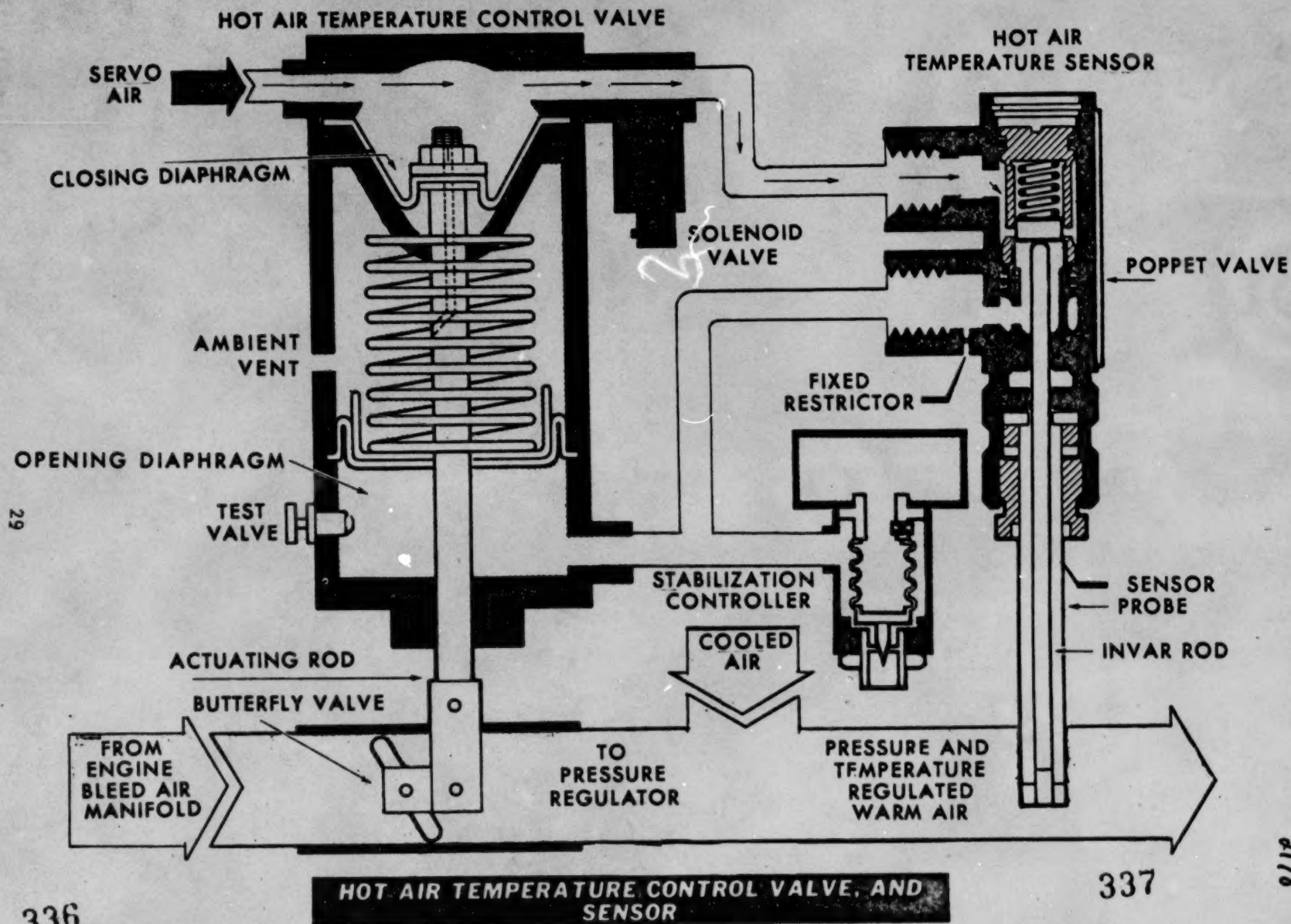


Figure 9.

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Correct Responses to Frame 16: 1. pneumatic, 2. close, 3. engine bleed, 4. hot air temperature control, 5. close

Frame 17

Figure 8 shows the hot air temperature control valve in the open position; less than 390°F duct temperature. Service air at a pressure of 55 PSI comes in the top of the valve and flows to the closing diaphragm. From the closing diaphragm, servo air will pass through the solenoid (deenergized) to the hot air temperature sensor. Servo air flows through the sensor to the stabilization controller and the opening diaphragm of the hot air temperature control valve. The opening diaphragm is much larger than the closing diaphragm so the servo air pressure will push the diaphragm up. The pressure overcomes the spring and closing diaphragm pressure opening the valve.

In the following statements, fill in the missing information in the spaces provided.

1. The hot air temperature control valve is actuated by air from the _____ system.
2. If the same pressure is applied to both the opening and closing diaphragms of the hot air temperature control valve, it will _____ (open/close).

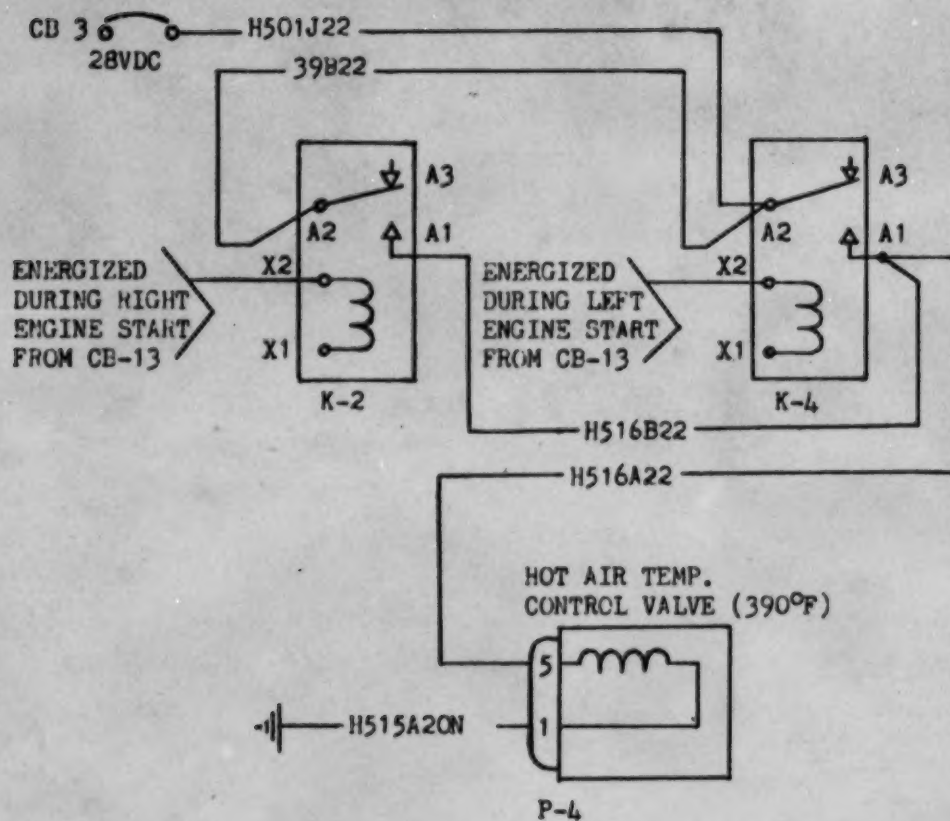


Figure 10.

Frame 18

If the duct temperature should rise more than 390°F the hot air temperature will close off the servo air to the hot air temperature control valve opening diaphragm. See figure 9. The servo air will push the closing diaphragm down and close the hot air temperature control valve. Servo air will then flow to the hot air temperature sensor. The hot air temperature sensor is shown when the duct temperature is more than 390°F. The hot air temperature sensor poppet valve shuts off servo air that would flow to the hot air temperature control valve opening diaphragm. With servo air pressure on the closing diaphragm and no air pressure on the opening diaphragm the valve will close.

During an engine start the hot air temperature control valve solenoid is energized. This will shut off the flow of servo air to the opening diaphragm the same way the hot air temperature sensor does.

You have learned how the hot air temperature control valve operates in the open and closed positions. During actual operation the hot air temperature sensor will control servo air to the hot air temperature control valve so it will modulate. This is how 390°F is maintained.

In the following statements, fill in the missing information in the spaces provided.

1. If duct temperature should rise more than 390°F the hot air temperature sensor will _____
(open up/close off) servo air to the hot air temperature control valve _____ (open/close) diaphragm.
2. During engine start the hot air temperature control valve solenoid is _____ (energized/deenergized).

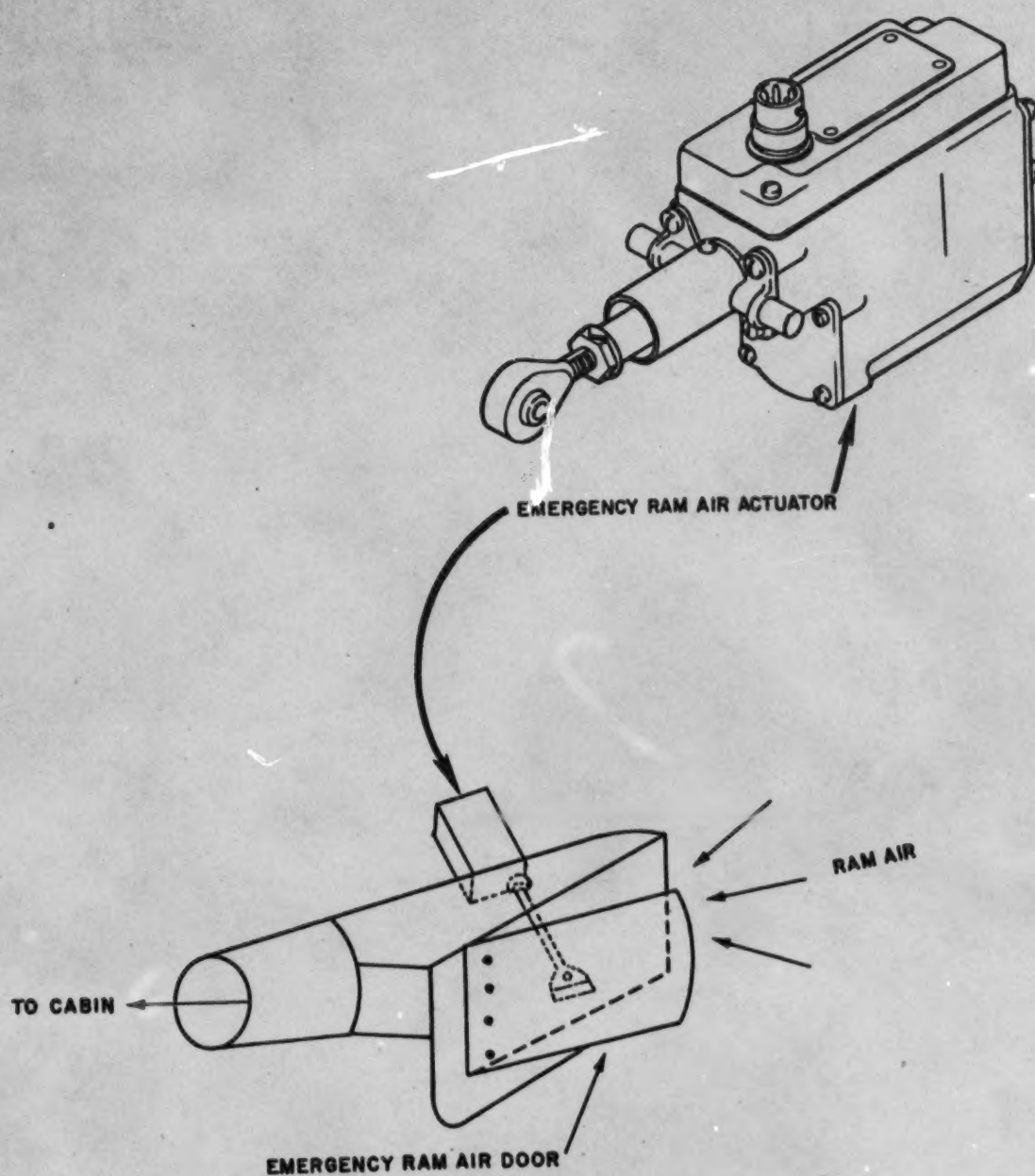


Figure 11.

Correct Response to Frame 19: None Required

Frame 20

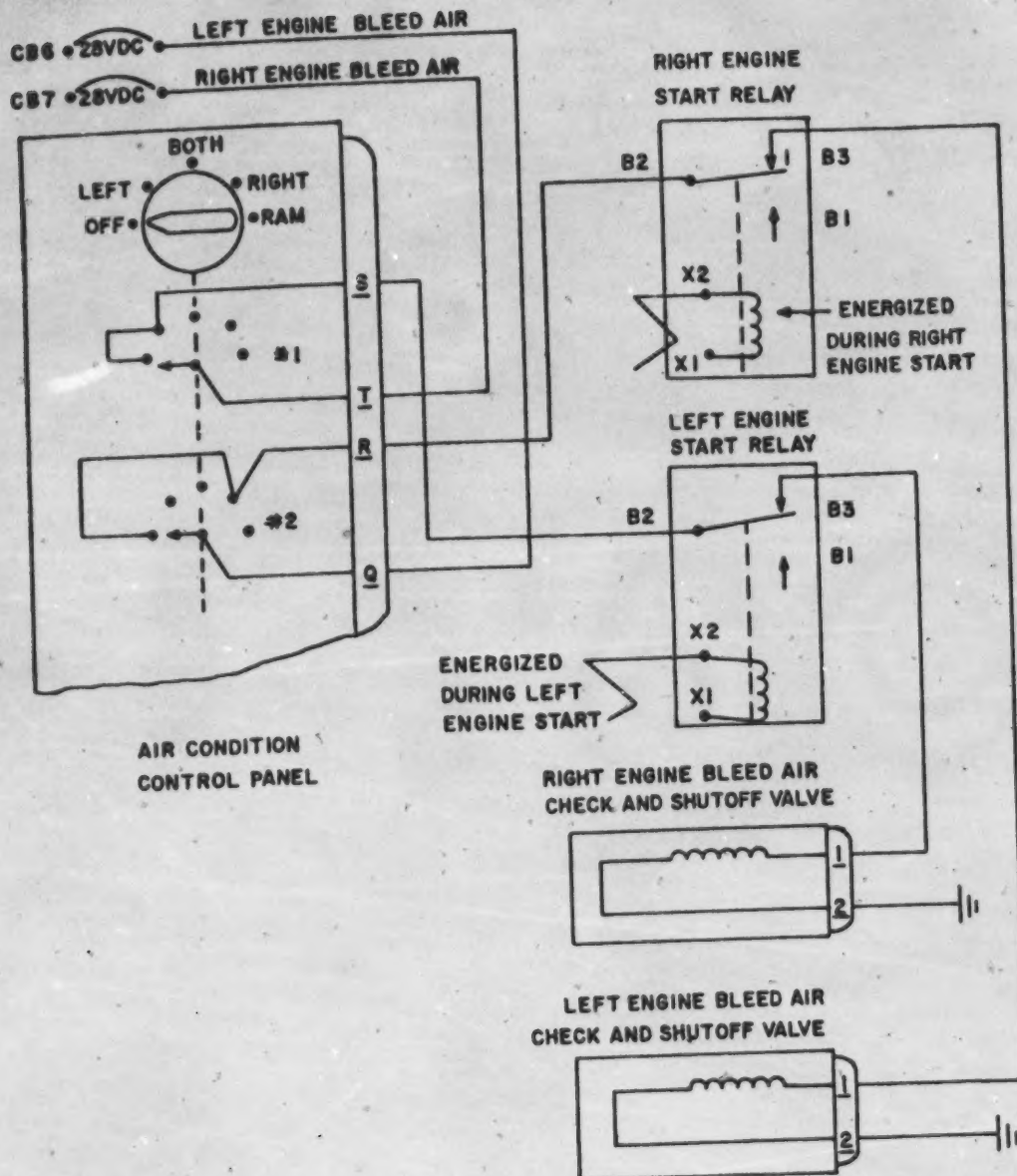
Now let us talk about the emergency ram air system. See figure 11. It consists of the emergency ram air door and the emergency ram air actuator. The emergency ram air system will supply emergency cooling and ventilating air to the cabin and equipment if the air conditioning system should fail. The emergency ram air system is controlled by the air source switch. Should the air conditioning system fail the pilot will place the air source switch to RAM. This will supply 115V AC to the emergency ram air actuator. Ram air can then be used for ventilation. See figure 11. Remember, when the air source switch is placed to RAM, the pressure regulating and SOV is energized closed.

In the following statements, fill in the missing information in the spaces provided.

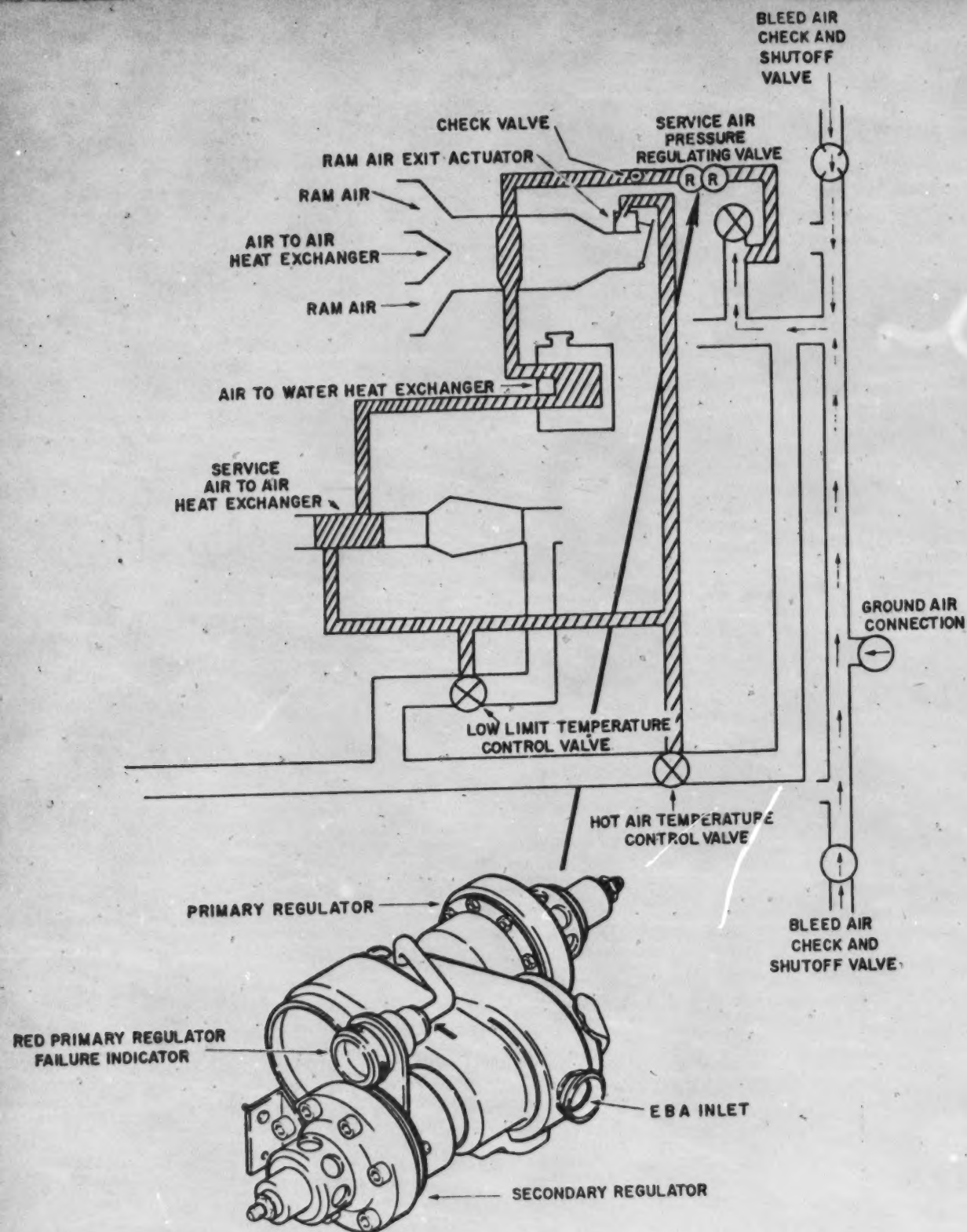
1. During an emergency, air for ventilation is provided by opening the _____.
2. The emergency ram air door is opened by the _____.

Correct Responses to Frame 20: 1. emergency ram air door,
2. emergency ram air actuator.

2185

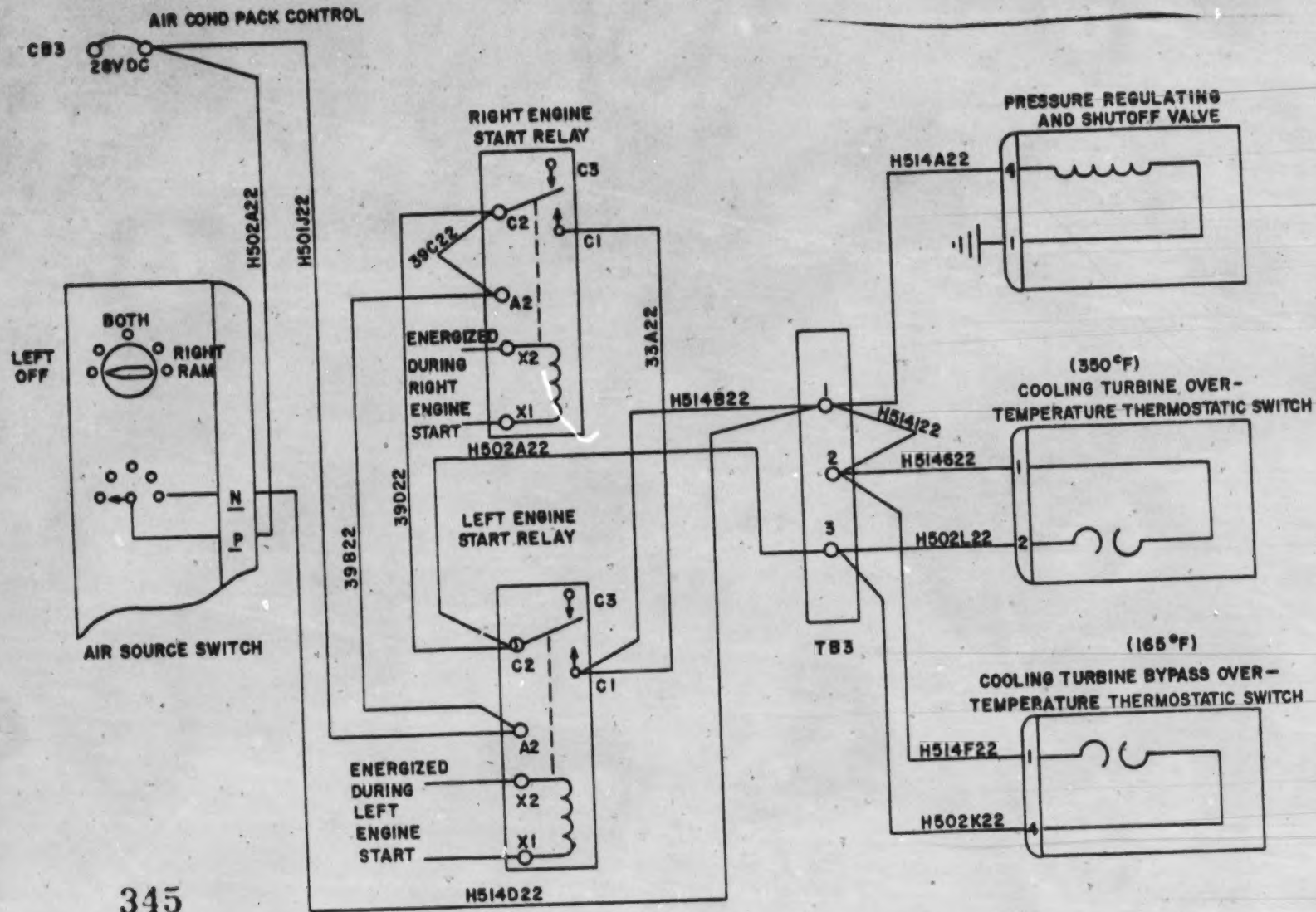


Foldout 1.



SERVICE AIR PRESSURE REGULATING VALVE

Foldout 2.



Foldout 3.

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ADVANCED FIGHTER-BOMBER AIR SOURCE CONTROL SYSTEM

OBJECTIVE

Given a wiring diagram and a workbook, analyze system operation, trace and analyze control circuits, and determine system malfunctions. From a list of statements and responses, select 70% of the responses correctly.

EQUIPMENT

Colored pencils

Basis of Issue
1/student

PROCEDURE

Open foldout #1. This is the wiring diagram for the air source system. In the programmed text (PT) you learned how the current flows through each of the circuits. An exception is the circuit that controls the emergency ram air door. This circuit is simple and will be discussed as the whole diagram is reviewed. Use the colored pencils to trace the circuits as shown by the color code on the foldout.

STEP-1

Use a red pencil to trace the power circuits. Check off each step as you trace it.

1. Trace from circuit breaker CB1 to the center contact of wafer 5 on the air source switch. _____.
2. Trace from circuit breaker CB3 to the center contact of wafer 3. _____.
3. Trace from CB3 to A2 of the left engine start relay. _____.
4. Trace wire number 39B22 to A2 of the right engine start relay and wire number 39022 to C2 of this relay. _____.
5. Trace from C2 on wire number 39D22 to C2 of the left engine start relay, and wire number H502A22 to Pin 3 of TB3. _____.

Supersedes 3ABR42231-WB-308A, 11 November 1975.

OPR: TAS

DISTRIBUTION: X

TAS - 250; TTVGC - 1

Designed for ATC Course Use. Do Not Use on the Job.

2/89

6. Trace from TB3 to Pin 2 of the cooling turbine inlet over-temperature switch and Pin 4 of the cooling turbine bypass over-temperature switch. -----.

7. Trace from circuit breaker CB6 to the center contact of wafer 2 of the air source switch. -----.

8. Trace from circuit breaker CB7 to the center contact of wafer 1.
-----.

These are the power circuits to the air source switch, the start relay contacts, and to the overtemperature switches.

STEP-2

Use a blue pencil to trace the circuits that are powered when the air source switch is placed to RAM. Check off each step as you trace it.

1. Draw all of the air source switch contacts (wafers 1 through 6) to the RAM position. On wafer 5 trace through Pin 1 to Pin 1 of the emergency ram air actuator. This opens the ram air door. -----.

2. On wafer 3 trace through Pin N to Pin 4 of the pressure regulator and shutoff valve (SOV). This energizes the solenoid, closing the valve. -----.

In the ram position of the air source switch, the emergency ram air door opens and the pressure regulator and SOV closes.

STEP-3

Use an orange pencil to draw the air source switch contacts to the RIGHT position. Check off each step as you trace it.

1. On wafer 5 trace through J to Pin 3 of the emergency ram air actuator, this closes the emergency ram air door. -----.

2. On wafer 2 trace through R to Pin B2 of the right engine start relay. -----.

3. This relay is not energized so go across the contact to B3 on to Pin 1 of the left engine bleed air check and SOV valve. This energizes the solenoid, closing the left engine bleed air check and SOV valve.

Notice power does not go to the right engine bleed air check and shutoff valve. So, in the right position the right engine bleed air check and SOV is deenergized open. Also, when the air source switch is placed to BOTH, the only circuit that gets power is the circuit closing the ram air door. You have already traced this circuit.

STEP-4

Use a brown pencil to draw the air source switch contacts to the LEFT position. Check off the step as you trace it.

1. On wafer 1 trace through S to B2 of the left engine start relay, across the contact to B3 and on to Pin 1 of the right engine bleed air check and shutoff valve. _____.

In the left position the right valve is closed. Notice when the air source switch is placed to OFF, both engine bleed air check and shutoff valve solenoids are energized and current is directed to close the ram door.

STEP-5

Now trace the circuit during left engine start. Use a purple pencil to trace the circuits. Check off each step as you trace it.

1. Draw the left engine start relay contact to the energized position (down). Notice that contact is broken between points B2 and B3 on the left relay which deenergizes the right engine bleed air check and SOV.

2. Trace power from C2 on the left engine start relay across the contact to C1 and on to Pin 4 on the pressure regulator and SOV. This closes the pressure regulator and SOV. _____.

3. Now trace from A2 on the left engine start relay across the contact to A1 and on to Pin 5 on the hot air temp control valve. This closes the hot air temperature control valves. _____.

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Now let us put it together. During left engine start the right engine bleed air check and SOV opens. The pressure regulator and SOV closes, and the hot air temperature control valves close. After the left engine is operating, the left engine start relay deenergizes and everything returns to normal.

STEP-6

Use a green pencil to trace the circuit during right engine start. During right engine start, the right engine bleed air check and SOV is energized. Check off each step as you trace it.

1. Draw the contacts in the right engine start relay to the down position.-----.

2. Trace power from C2 across the relay contact to C1 and along the wire to C1 on the left engine start relay.-----.

3. From C1 on the left engine start relay the power goes to Pin 4 on the pressure regulator and SOV. -----.

Notice the same wire is used to send power to the pressure regulator and SOV from the left engine start relay. Notice the middle contact on the right engine start relay breaks the circuit to the left engine bleed air check and SOV during right engine start.

4. On the lower contacts of the right engine start relay follow power from Pin A2 across the contact to A1.-----.

5. Trace power to A1 on the left engine start relay and on to Pin 5 on the hot air temperature control valve. -----.

Once again during engine start, the pressure regulator and SOV and the hot air temperature control valves are closed. The only difference in the right engine start was opening the left engine bleed air check and SOV instead of the right.

The only circuit that you have not traced is from the overtemperature switches to the pressure regulator and shutoff valve. Note, there is power at both switches and if either switch closes, power is directed to the pressure regulator and shutoff valve solenoid. Keep in mind, in the case of an overtemperature condition, this will close the pressure regulator and shutoff valve.

Note: On the wiring diagram, the electrical connector (P-23) for the AIR CONDITION CONTROL PANEL has the pins marked with a line under the letter, such as S. This means that when you go to the connector on the trainer, the connector pin will be marked with a lower case letter, such as "s". This concept is used on all of the advanced fighter-bomber aircraft wiring diagrams. When you go to the trainer for troubleshooting, just remember, S will be "s" on the connector.

STEP-7

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There are 12 circled numbers on foldout #1 that show opens or shorts in a circuit. These point to a part that may have an open or short in the internal circuit of the part. Below are 10 statements of troubles in the air source system. Read the trouble statement then select the trouble number or numbers that can cause the condition given. Some troubles may have more than one cause.

1. _____ The hot air temp control valve does not close when starting either engine.
2. _____ The ram air door fails to open when the air source switch is placed to RAM.
3. _____ The left engine bleed air check and shutoff valve stays open at all times.
4. _____ The pressure regulator and shutoff valve will not open.
5. _____ The pressure regulator and shutoff valve stays open when the air source switch is placed to RAM, but closes normally during engine start.
6. _____ The pressure regulator and shutoff valve does not close when starting either engine. The hot air temperature control valve does not close when starting the right engine, but does close when starting the left engine.
7. _____ The air conditioning system does not turn off when the turbine inlet temperature exceeds 350° F.
8. _____ The right engine bleed air check and shutoff valve stays open at all times.
9. _____ The hot air temp control valve and the pressure regulator and shutoff valve both stay open when starting engines.
10. _____ The pressure regulator and shutoff valve stays open when starting the right engine. The valve closes normally when starting the left engine.

Check with your instructors for the correct responses.

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CB1 115VAC RAM AIR

H500A22

CB3 28VDC AIR COND. PACK CONTROL

H501J22

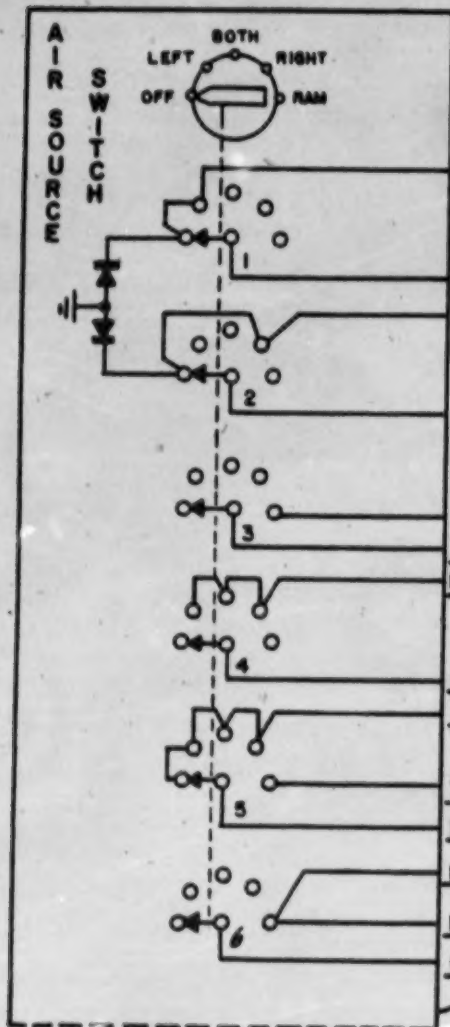
H502A22

CB6 28VDC L. ENGINE BLEED AIR

H505A22

CB7 28VDC R. ENGINE BLEED AIR

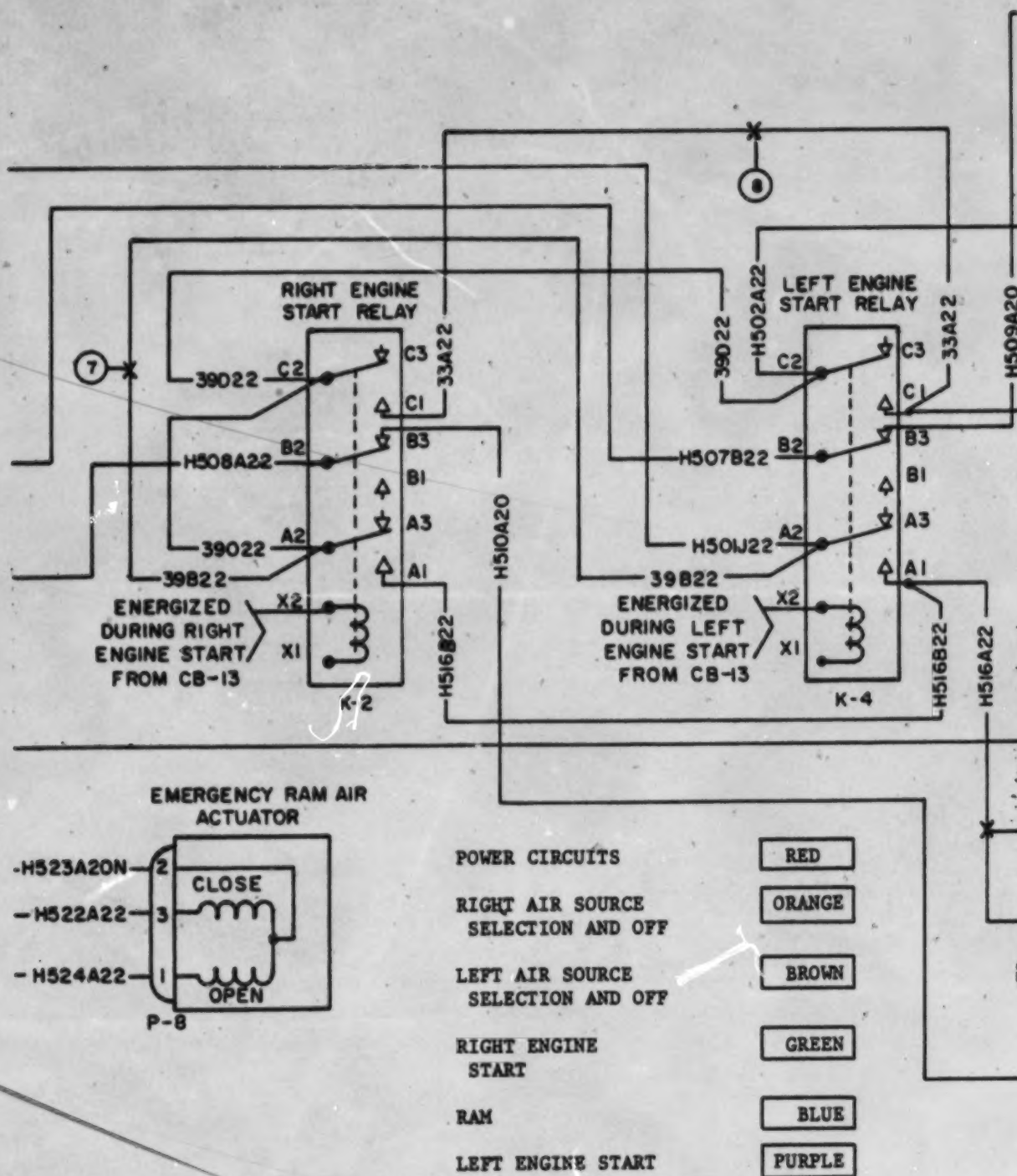
H506A22



AIR CONDITION CONTROL PANEL

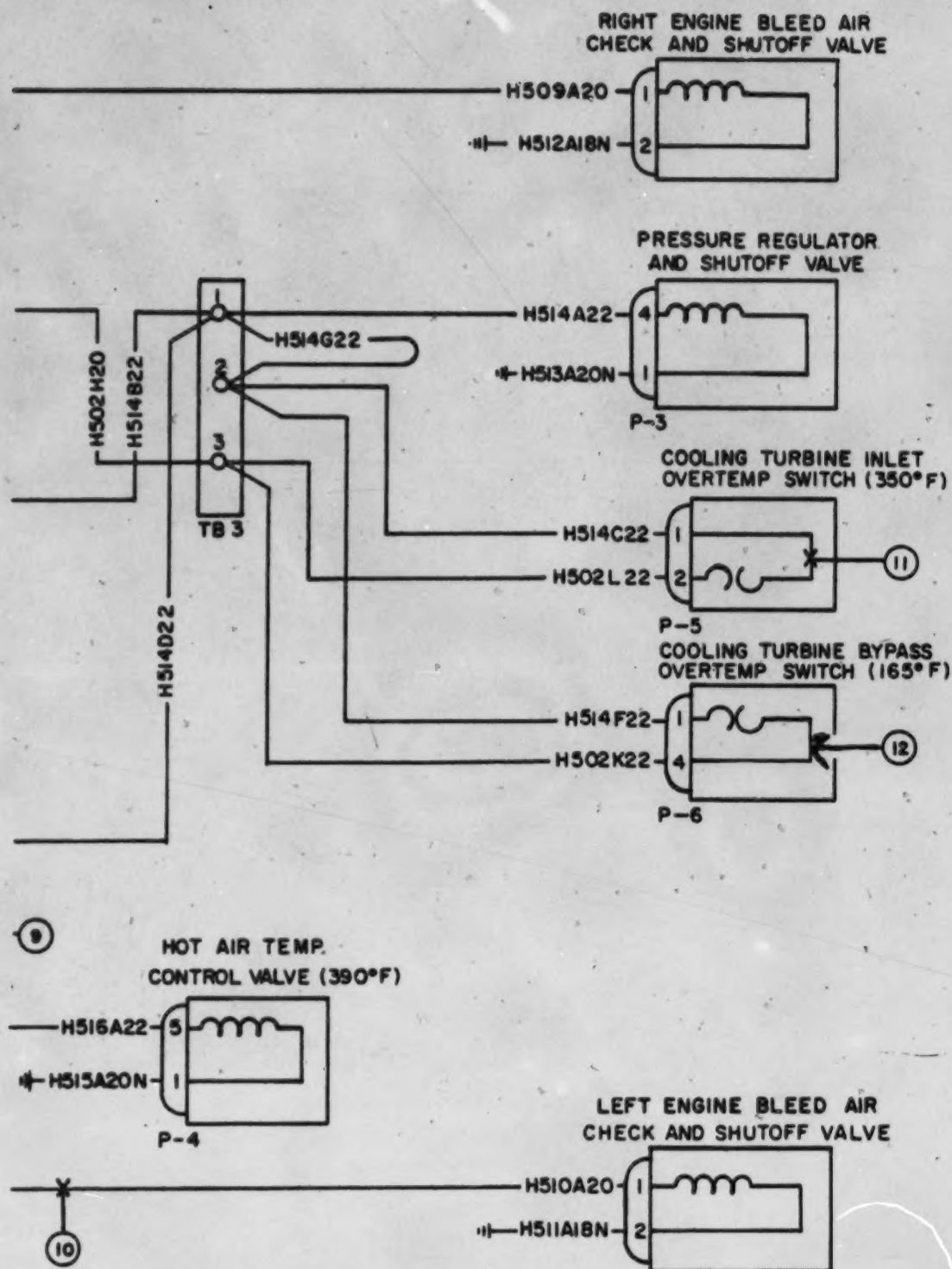
Foldout 1. Section 1.





AIR SOURCE CONTROL CIRCUITS

Foldout 1. Section 2.



Foldout 1, Section 3.



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WORKBOOK

3ABR42331-WB-308

Technical Training

Aircraft Environmental System Mechanic

ADVANCED FIGHTER BOMBER AIR SOURCE CONTROL SYSTEM
OPERATIONAL CHECK AND TROUBLESHOOTING

2 December 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

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2197

Environmental Pneudraulic Branch
Chanute AFB, Illinois

3ABR42231-WB-308

ADVANCED FIGHTER BOMBER AIR SOURCE CONTROL SYSTEM
OPERATIONAL CHECK AND TROUBLESHOOTING

OBJECTIVES

After you have completed this workbook, you will be able to:

1. Make an operational check of the air source control system using a trainer to find the condition of the listed parts. Make the check during the engine start sequence, and normal air source selection operations.
 - a. Bleed air check and shutoff valves.
 - b. Pressure regulator and shutoff valve.
 - c. Hot air temperature (temp) control valve.
 - d. Emergency ram air door.
 - e. Air source control switch.
 - f. Cooling turbine overtemp switches.
2. Identify air source control system malfunctions using a trainer.
3. Troubleshoot the air source control system using a multimeter, wiring diagram and trainer.

Standard of Performance

Correctly determine malfunctioning parts by locating the cause for 2 of 3 selected problems.

EQUIPMENT

	Basis of Issue
Trainer 4024, Advanced Fighter Bomber Air Conditioning System	1/student
Multimeter	1/student
Wiring Diagram, Air Source Control	1/student

Supersedes 3ABR42231-WB-308, 14 November 1973, which may be used until existing stocks are exhausted.

OPR: TASTC

DISTRIBUTION: X

TASTC - 500; TTVGC -1

PROCEDURE

1. Remove all your jewelry now.
2. Go to the laboratory (lab) instructor and inform him of the lesson you are working on.
3. This workbook is in three sections. Complete the first section before going to the other sections.

SECTION

TITLE

- | | |
|-----|--|
| I | Location and Identification of Air Source Control System Parts |
| II | Air Source Control System Operational Check |
| III | Troubleshooting |

SECTION I

Location and Identification of
Air Source Control System Parts

PROCEDURE

1. Using the trainer and figure 1, find each of the listed parts. Write the number that goes with the name of each part in the blank space. As you find the parts follow the flow of air from the engines and ground start connection. The flow of air is through the refrigeration unit and the refrigeration bypass duct.

- a. _____ Ground start check valve.
- b. _____ Left engine bleed air check and shutoff valve.
- c. _____ Simulated right engine bleed air check and shutoff valve.
- d. _____ Air conditioning system pressure regulator and shutoff valve.
- e. _____ Hot air temperature control valve.
- f. _____ Hot air temp sensor.
- g. _____ Service air pressure regulator.
- h. _____ Cooling turbine inlet overtemp switch.
- i. _____ Simulated turbine bypass valve.
- j. _____ Cooling turbine bypass overtemp switch.
- k. _____ Bleed air low pressure switch.

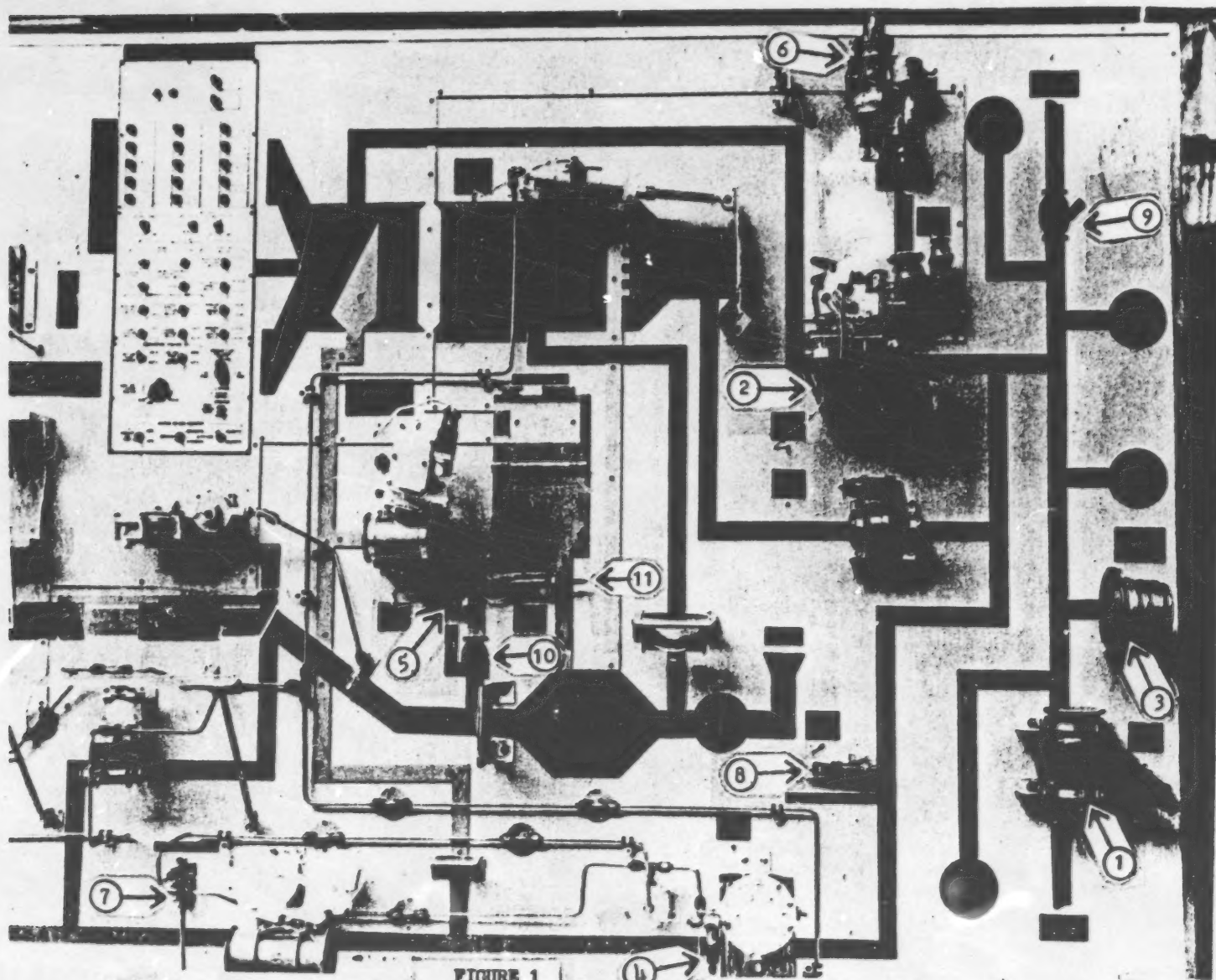


FIGURE 1

2. Using the trainer and figure 2, find each of the listed parts. Write the number that goes with the name of each part in the blank space.

- a. _____ Trainer power switch.
- b. _____ Engine start switches.
- c. _____ Engine starter cutout switches.
- d. _____ Turbine bypass overtemp simulation switch.
- e. _____ Turbine inlet overtemp simulation switch.
- f. _____ Air source switch.
- g. _____ Hot air temp sensor simulation switch.
- h. _____ Bleed air pressure simulation switch.
- i. _____ Altitude simulation switch.

3. Using the trainer and figure 3, find each of the listed parts. Write the number that corresponds to the name of each part in the blank space.

- a. _____ Emergency ram air door.
- b. _____ Emergency ram air actuator.

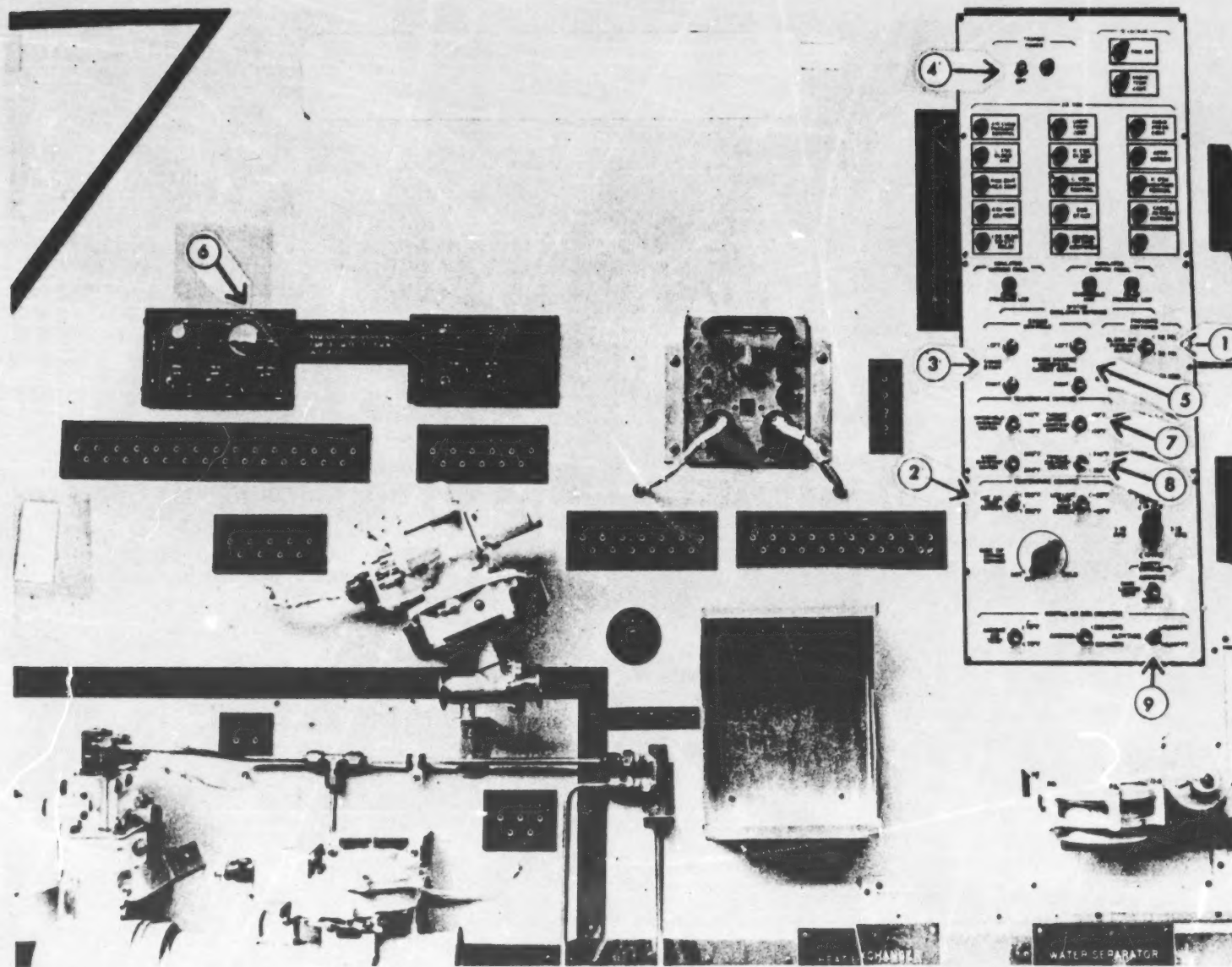
Note: Symbols are used (on some switches) to show more than or less than some set value. The symbol "<" means less than, and the symbol ">" means more than. For example, the hot air temp sensor simulation switch is marked < 390°F and > 390°F. When in the < 390°F position the system will work at a temperature LESS than 390°F. When in the > 390°F position the system will work at a temperature MORE than 390°F.

Answers to Step 1: a. 3 b. 1 c. 9 d. 2 e. 4 f. 7

g. 6 h. 11 i. 10 j. 5 k. 8

Answers to Step 2: a. 4 b. 3 c. 5 d. 7 e. 8 f. 6

Answers to Step 3: a. 2 b. 1



2201

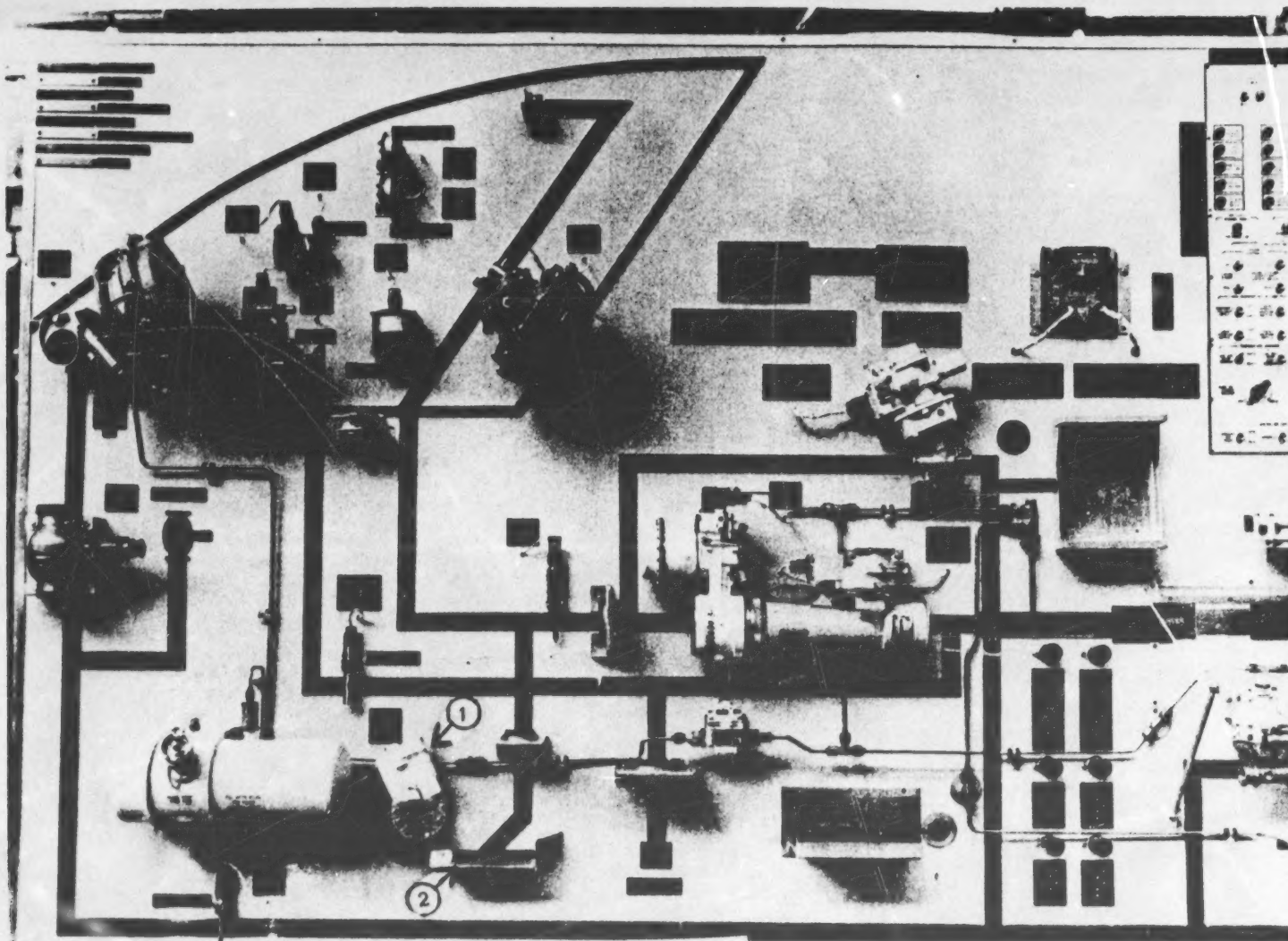


Figure 3

SECTION II

Air Source Control System
Operational Check

PROCEDURE

When you make an operational check or troubleshoot the system and you find that a valve does not work, recheck the position of the circuit breakers and switches. Check the electrical circuits for correct operation. Use the self-test feature to check the valve. If the system still does not work, the valve is bad. Let the instructor know of the problem. Follow the step by step procedure for operating the air source control system. Be sure to do each step as told. If you have any type of problem, ask the instructor for help.

1. Preparation

a. Get the air source control wiring schematic and a multimeter from the wall locker in the F-111 laboratory.

b. Connect the trainer electrical leads found on the left end of the trainer to the wall receptacles behind the trainer.

c. Push in all trainer circuit breakers.

Note: Since there is a flow of air through the system, we also have service air. Keep in mind that the hot air temp control valve is moved by service air. It can be checked with the self-test button. Find the self-test button on the hot air temp control valve.

d. Trainer start operation.

e. Position switches as follows:

SWITCH	LOCATION	POSITION
Trainer power switch	Above C/B panel	OFF
Bleed air pressure switch	Simulation panel	> 30 PSI
Turbine bypass overtemp switch	Simulation panel	< 170°F
Turbine overtemp switch	Simulation panel	< 350°F
Hot air temperature sensor	Simulation panel	< 390°F
Air source switch	A/C control panel	OFF
Altitude switch	Simulation panel	< 10,000 ft
Trouble switches	Left end of trainer	DOWN POSITION
Trainer air supply	On wall behind trainer	ON (turn counter-clockwise)

2. Operational Check

CONTROL DEVICE AND POSITION	OPERATING COMPONENT	POSITION
Place trainer power switch to ON	Power Light	ON

Note: With a ground air source cart, you can work the air conditioning system on the ground when the engines are not running. We will use the ground air source cart to start the left engine.

Continue the operational check

CONTROL DEVICE AND POSITION	OPERATING COMPONENT	POSITION
Place ground air source simulation switch to ON	Lights in simulated ducting should show airflow	See Note

Note: The lighting will show the flow of air to the engine bleed air check and shutoff valves and the engine starter valves. Airflow also goes through the refrigeration unit and hot air temperature control valve.

2205

CONTROL DEVICE AND POSITION	OPERATING COMPONENTS	POSITION
Hot air temp control valve self-test button.	Hot air temp control valve	Closed
Release self-test button	Hot air temp control valve	Open
Press left engine start switch to ON momentarily	Pressure regulator and shutoff valve Hot air temp control valve Left engine bleed air check and shutoff valve solenoid Right engine bleed air check and shutoff valve solenoid	Closed Closed Energized (Closed) Deenergized (Open)
Press left engine starter overspeed cutout switch to ON momentarily	Pressure regulator and shutoff valve Hot air temperature control valve Left and right engine bleed air check and shutoff valve solenoids	(Open) (Open) Energized
Place ground air source simulated switch to OFF	Lights should indicate air is available at the left engine bleed air check and shutoff valve. This means the left engine is running. Engine bleed air from the left engine will be used to start the right engine.	

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Continue the operational check

2206

CONTROL DEVICE AND POSITION	OPERATING COMPONENTS	POSITION
Press the right engine start switch to ON momentarily	Pressure regulator and shutoff valve	Closed
	Hot air temperature control valve	Closed
	Left engine bleed air check and shutoff valve solenoid	Deenergized Open
	Right engine bleed air check and shutoff valve solenoid	Energized Closed
Press right engine starter overspeed cutout switch to ON momentarily	Left and right engine bleed air check and shutoff valve solenoids	Energized Closed
	Lights should indicate bleed air is available at both engine bleed air check and shutoff valves	Energized Closed

Complete the following questions:

1. When starting the left engine from the ground air source, are either of the bleed air check and shutoff valves solenoids energized?
_____ (yes/no)
2. When starting the right engine, with the left engine operating, are either of the bleed air check and shutoff valves open? _____
(yes/no). If yes, which one? _____
3. When starting engines, should the hot air temperature control valve open or close? _____
4. When starting engines, the pressure regulator and shutoff valve is closed as a result of the engine start relays _____
(energizing/deenergizing) and the pressure regulator and shutoff valve solenoid _____ (energizing/deenergizing).

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Answers to Questions:

1. Yes 2. Yes (The left engine bleed air check and shutoff valve is open permitting air to flow from the left engine to the right engine starter.)

3. Close 4. Energizing Energizing

Continue the operational check

CONTROL DEVICE AND POSITION	OPERATING COMPONENT	POSITION
Place the air source switch to LEFT	Pressure regulator and shutoff valve	Open
	Hot air temperature control valve	Open
	Left engine bleed air check and shutoff valve solenoid	Deenergized Open
	Right engine bleed air check and shutoff valve solenoid	Energized Closed
Place the air source switch to RIGHT	Pressure regulator and shutoff valve	Open
	Hot air temperature control valve	Open
	Left engine bleed air check and shutoff valve solenoid	Energized Closed
	Right engine bleed air check and shutoff valve solenoid	Deenergized Open

Complete the following questions:

1. With the air source switch in LEFT, the left engine bleed air check and shutoff valve solenoid should be _____ (energized/deenergized) and the right bleed air check and shutoff valve solenoid should be _____ (energized/deenergized).

2. With the air source switch in BOTH, the engine bleed air check and shutoff valve solenoids should be _____ (energized/deenergized).

2208

3. An OPEN in the solenoid coil of the left engine bleed air check and shutoff valve would cause the valve to:

- a. remain OPEN at all times.
- b. remain CLOSED at all times.
- c. OPEN only when the left engine is operating.
- d. CLOSE only when the left engine is operating.

Answers to Questions: 1. deenergized, energized 2. deenergized

3. c

Continue the operational check

CONTROL DEVICE AND POSITION	OPERATING COMPONENT	POSITION
Place the air source switch to RAM	Pressure regulator and shutoff valve	Closed
	Hot air temperature control valve	Open
	Left and right engine bleed air check and shutoff valve solenoids	Deenergized Open
	RAM air door	Open (in 60 sec)

Note: In actual system operation, if the air entering or bypassing the turbine exceeds a given value, the overtemp switch will cause the pressure regulator and shutoff valve to close. We can simulate the action of the overtemp switches on the trainer by using the switches marked turbine bypass overtemp switch and turbine overtemp switch.

2209

Continue the operational check

CONTROL DEVICE AND POSITION	OPERATING COMPONENT	POSITION
Place the air source switch to BOTH	Pressure regulator and shutoff valve	Open
Place simulated turbine (inlet) overtemp switch to $>350^{\circ}\text{F}$.	Pressure regulator and shutoff valve	Closed
Place simulated turbine (iglet) overtemp switch to $<350^{\circ}\text{F}$.	Pressure regulator and shutoff valve	Open

NOTE: Air flows through the turbine bypass valve only when the bleed air manifold pressure is below 30 PSI and the aircraft altitude is below 10,000 ft. These two conditions can also be simulated by the simulation switches.

Continue the operational check

CONTROL DEVICE AND POSITION	OPERATING COMPONENT	POSITION
Place the simulated bleed air pressure switch to $<30\text{ PSI}$	Turbine bypass valve	Open light indicates valve open
Place the altitude simulating switch to $>10,000\text{ ft}$	Turbine bypass valve	Closed
Place the simulated bleed air pressure switch to $>30\text{ PSI}$	Turbine bypass valve	Closed
Place the turbine bypass overtemp switch to $>170^{\circ}\text{F}$	Pressure regulator and shutoff valve	Closed
Place the turbine bypass overtemp switch to $<170^{\circ}\text{F}$	Pressure regulator and shutoff valve	Open

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Complete the following questions:

22/0

1. The ram air door takes more than 60 seconds to open, this would mean a defective _____.

2. When the air source switch is placed in RAM, does this close the bleed air check and shutoff valves? _____ (yes/no)

3. If the turbine inlet air temperature is more than 350°F, the overtemp switch will close the _____.

4. If the aircraft is flying below 10,000 ft and the bleed air duct pressure drops below 30 PSI, the _____ will open.

5. When the turbine bypass valve is open, if the bypass air temperature is more than 165°F, the _____ will close.

Answers to Questions : 1. ram air door actuator 2. No
3. pressure regulator and shutoff valve
4. turbine bypass valve
5. pressure regulator and shutoff valve

Continue the operational check

Note: If the temperature of the air that flows past the hot air temperature sensor is more than 390°F, the hot air temperature control valve will move toward the closed position. Movement of the valve reduces the flow of bleed air. On the trainer we can simulate a temperature more than 390°F, however, the valve will not modulate, but close all the way. This does give a check of the valve and the sensor.

2211

Continue the operational check

CONTROL DEVICE AND POSITION	OPERATING COMPONENT	POSITION
Place the hot air temperature sensor simulating switch to >390°F	Hot air temperature control valve	Closed
Place the hot air temperature sensor simulating switch to <390°F	Hot air temperature control valve	Open

Note: When inspecting the air conditioning system, the pressure regulator and shutoff valve should be checked for indicating overpressure. Find the overpressure indicator on the pressure regulator and shutoff valve. If the indicator is out, this means the pressure is more than 165 PSI. The service air pressure regulator also has an overpressure indicator. Find the service air pressure regulator overpressure indicator. If the indicator is out, the pressure is more than 66 PSI.

Complete the following questions:

1. When the temperature of the air bypassing the refrigeration unit is more than 390°F, the hot air temperature control valve should modulate toward _____.
2. If the hot air temperature control valve stays closed at all times, it indicates one of the following; a loss of service air; a malfunctioning _____; or a malfunctioning hot air temperature sensor.
3. If the overpressure indicator on the service air pressure regulator is out, it indicates the pressure is more than _____.

Answers to Questions:

1. closed
2. service hot air temperature control valve
3. 66 PSI

SECTION III

Air Source Control System
Troubleshooting

PROCEDURE

The trouble switches you are to use are listed on the Form 781A, given to you by the instructor. Place one trouble in the system at a time then make a complete operational check. Find the part or parts that are malfunctioning and the cause of the malfunction. In the DISCREPANCY BLOCK of the Form 781A, print the name of the part that is malfunctioning. In the CORRECTIVE ACTION BLOCK, state the action you would take to correct the problem. As an example, suppose the right engine bleed air check and shutoff valve fails to close. You find the cause to be an open in wire number H509A20. In the DISCREPANCY BLOCK you would state: Right engine bleed air check and shutoff valve stays open with the air source switch OFF. In the CORRECTIVE ACTION block you would state: Repaired wire number H509A20. Operational checked OK IAW TO.

Note: An underlined capital letter on the wiring schematic stands for a small letter on the fighter bomber trainer patch panel.

EXAMPLE: A on the schematic = a on the trainer patch panel.

A capital letter not underlined on the wiring schematic represents a capital letter on the trainer patch panel.

EXAMPLE: A on the schematic = A on the trainer patch panel.

Analyze the first trouble listed on AFTO Form 781A. When you are done with the listed troubles, complete an AFTO Form 349 and the AFTO Form 781A and have the instructor check your work. After you fill in the AFTO Form 781A, go to the locker and get TO 1F-111A-06, Code Manual. Fill out an AFTO Form 349 on a trouble selected by the instructor. Have the instructor check your work.

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Information necessary for the completion of AFTO Form 781A and
AFTO Form 349.

BLOCK	ITEM NUMBER	ENTRY
1	Job Control no.	1162314
2	Work center	360
3	I.D. No/Serial No.	MA6033
7	PRI.	2A
9	Location	A1
B	Type Maint.	B
E	When Disc.	In Flight-No Abort

375

DATE FROM		TO		CREW CHIEF		ORGN		LOCATION		MDS		SERIAL NO.	
SYM	DATE DISCD	WDC	JCN	TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE		TRANSFERRED BY			
DISCREPANCY						CORRECTIVE ACTION							
						DATE CORRECTED							
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	
SYM	DATE DISCD	WDC	JCN	TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE		TRANSFERRED BY			
DISCREPANCY						CORRECTIVE ACTION							
						DATE CORRECTED							
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	
SYM	DATE DISCD	WDC	JCN	TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE		TRANSFERRED BY			
DISCREPANCY						CORRECTIVE ACTION							
						DATE CORRECTED							
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	
SYM	DATE DISCD	WDC	JCN	TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE		TRANSFERRED BY			
DISCREPANCY						CORRECTIVE ACTION							
						DATE CORRECTED							
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	

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PAGE OF PAGES

DATE FROM		TO		CREW CHIEF		ORGN		LOCATION		MDS		SERIAL NO.	
SYM		DATE DISCD		WDC		JCN		TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE	
DISCREPANCY												TRANSFERRED BY	
												DATE CORRECTED	
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	
SYM		DATE DISCD		WDC		JCN		TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE	
DISCREPANCY												TRANSFERRED BY	
												DATE CORRECTED	
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	
SYM		DATE DISCD		WDC		JCN		TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE	
DISCREPANCY												TRANSFERRED BY	
												DATE CORRECTED	
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	
SYM		DATE DISCD		WDC		JCN		TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE	
DISCREPANCY												TRANSFERRED BY	
												DATE CORRECTED	
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	
SYM		DATE DISCD		WDC		JCN		TAG NO.		CF TO 781A DATED		TRANSFERRED TO 781K DATE	
DISCREPANCY												TRANSFERRED BY	
												DATE CORRECTED	
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	

AFTO FORM 781A
MAY 73

MAINTENANCE DISCREPANCY AND WORK DOCUMENT

PREVIOUS EDITION
IS OBSOLETE

PREPARE THE MAN



PROGRAMMED TEXT

3ABR42331-PT-309

Technical Training

Aircraft Environmental Systems Mechanic

FIGHTER BOMBER AIR CONDITIONING SYSTEM

15 January 1976



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42231 instructional system. The material contained herein has been validated using 33 42010 students enrolled in the 3ABR42231 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 7.5 hours to complete this text.

OBJECTIVES

After completion of this programmed text you will be able to:

1. Select statements that identify the function of each component in the fighter bomber air conditioning system.
2. Trace electrical circuits for control of the hot and cold air modulating valves, minimum flow pressure switch, ram air exit door and turbine bypass valve.

Standard of performance:

Correctly identify purpose of system components and analyze system electrical circuitry with 75% accuracy.

INSTRUCTIONS

This programmed text presents information in steps called frames. After each frame you will complete a statement, select a true or false statement, or match statements. Read the material and make your response as directed. After your response compare your answer with the correct answer given at the top of the even numbered pages. If your answer is incorrect, restudy the frame. Write the correct answer next to your original response and then proceed to the next frame. If necessary, you may go back to check information previously given, but do not skip ahead.

Supersedes 3ABR42231-PT-309, 31 May 1974, which may be used until existing stocks are exhausted.

OPR: TASTC

DISTRIBUTION: X

TAS - 500; TTVGC - 1

The purpose of the air conditioning system is to send conditioned air to the cabin and electronic compartments. The air conditioning system can be divided into two separate paths for air flow. These two paths will be known as the hot and cold air systems. Both the hot and cold air is pressure regulated and temperature controlled. The two paths are joined at various points to form one air conditioning system. In the back of this text is foldout 1 of the whole air conditioning system. Use this foldout as a reference when you study the parts of the system.

Answer statements as True (T) or False (F).

- ___ 1. There are two separate air conditioning systems.
- ___ 2. The air conditioning system is made of two separate paths for air flow.
- ___ 3. The purpose of the air conditioning system is to give a source of conditioned air to the cabin and electronic compartments.

2219

CORRECT RESPONSES TO FRAME 1: 1. F 2. T 3. T

Frame 2

We will discuss the cold air part of the system first. Figure 1 shows how the system is laid out. Engine bleed air from one or both engines can be used for air conditioning. From the left and right bleed air check and shutoff valves bleed air goes to the pressure regulator and shutoff valve. This valve is normally deenergized open. It regulates to 165 psi the air pressure going to the air-to-air heat exchanger. Here is where the first stage of cooling starts. The pressure regulator and shutoff valve is energized closed when: (1) there is an overheat condition in the system, (2) the system is in "ram", (3) starting the engines.

1. Air is routed through the left and right _____
_____ and _____ valves.
2. The pressure regulating and shutoff valve is closed during
engine _____, when system is in _____ or when
an _____ condition exists.

Pressure Regulator &
Shutoff Valve

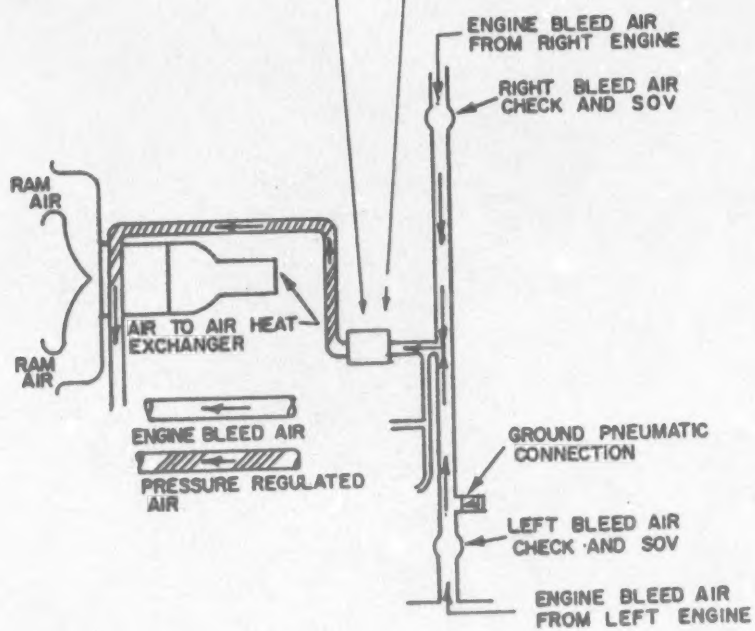


Figure 1.

2221

CORRECT RESPONSES TO FRAME 2: 1. bleed air check shutoff
2. start ram overheat

Frame 3

The engine bleed air (EBA) temperature is reduced as it passes through the core of the air-to-air heat exchanger. The exchanger has an ejector that increases the effectiveness by increasing ram air flow around the cores. Air pressure to the ejector nozzles is supplied through the compressor of the cooling turbine. From the air-to-air heat exchanger, the partially cooled air moves through a cold air modulating valve. From here the air flows to the water tank.

Fill in the blanks.

1. The ejector _____ the effectiveness of the _____
_____.
2. The engine bleed air passes _____ the _____ of
the air-to-air heat exchanger.
3. Air pressure to the ejector is supplied through the _____
of the _____.

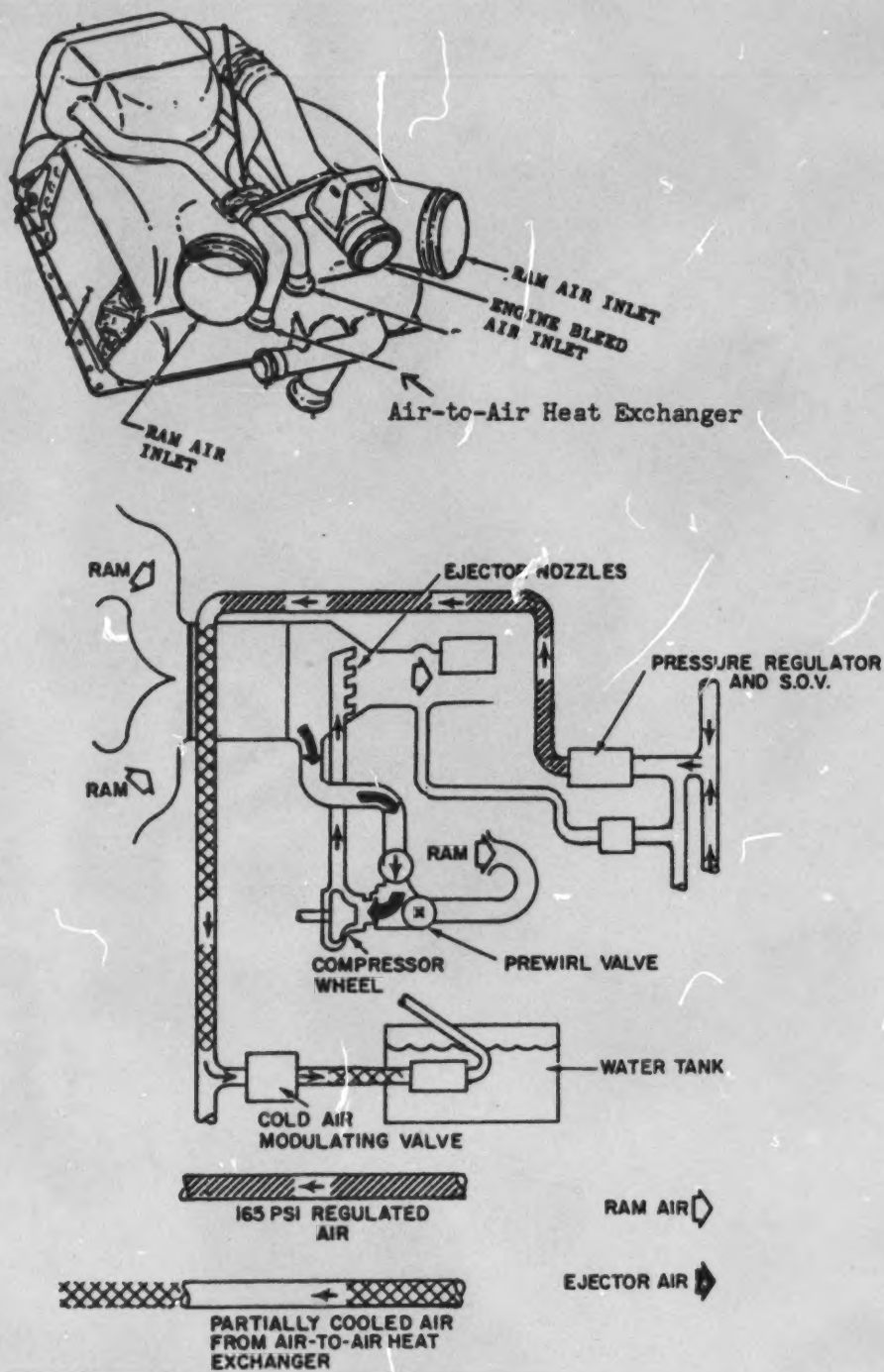


Figure 2.

- CORRECT RESPONSES TO FRAME 3:
1. increases, heat exchanger
 2. through, core
 3. compressor, cooling turbine

Frame 4

The flow of ram air through the air-to-air heat exchanger is controlled by the ram air exit door (figure 3). The door is extended or retracted by an air operated actuator. The actuator is controlled by the RAM AREA switch that is in the cockpit, on the air conditioning control panel. The switch has two positions normal and override. In the normal position the actuator is controlled by the central air data computer (CADC). In the override position the actuator is controlled manually and the computer is cut out of the system.

When the CADC is in control, the exit door will be extended when the ram air temperature through the heat exchanger is more than 75 degrees F or when air speed is less than 225 knots. The door will be retracted when the ram air temperature is less than 75 degrees F or air speed is more than 225 knots. When the door is retracted, only 65% of the opening is covered. This is so the air-to-air heat exchanger will always have some cool ram air flow around the cores.

Answer the statements as True (T) or False (F).

- _____ 1. The ram area switch has two positions, normal and override.
- _____ 2. The exit door will be retracted when air temperature is above 75° F.
- _____ 3. When the ram area switch is in the normal position, the CADC controls the door positions.

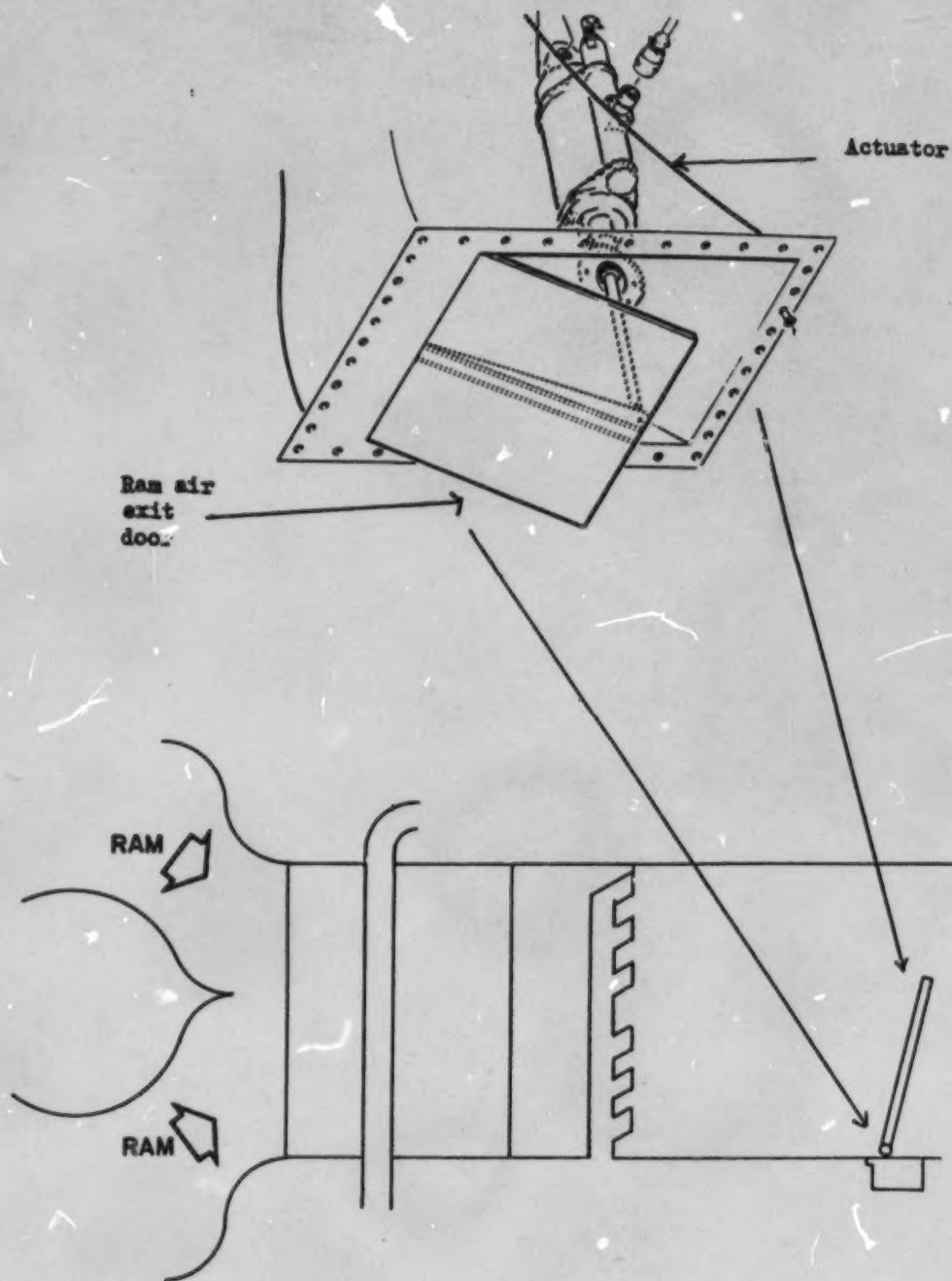


Figure 3.

Frame 5

Figure 4 shows the electrical diagram for the ram air exit door. Current comes through relay K6 to extend or retract the ram air exit door. Use a red pencil to trace this circuit. 28V DC is at circuit breaker CB9. From the circuit breaker current flows through wire #H100A22 to the ram area switch. From the ram area switch current goes out of pin S on wire #H100C22 to A2 of the K6 relay. Use a blue pencil to trace the next circuit. Draw the ram area switch to the override position. With the ram area switch in this position the K6 relay will be deenergized and the circuit will be from A2 to A3 of the relay. Current will flow through wire #H107A22 and extend the ram air exit door. Use a green pencil to trace the next circuit. Draw the ram area switch to the normal position. In this position the ram area switch will now allow the CADC to control the K6 relay. The position of K6 relay will determine the position of the ram air exit door. Draw in the circuit from the ram area switch through wire #H101A22 to the CADC. As long as the air speed of the aircraft is less than 225 knots or temperature is more than 75° F the CADC will not energize the K6 relay and the ram air exit door will stay extended. However, should airspeed increase to more than 225 knots or temperature fall below 75°V the CADC will energize the K6 relay through wire #H102A22. Current to the coil of the K6 relay will close a circuit between A2 and A1 contacts of the relay. Current flow goes through wire #H106A22 to retract the ram air exit door.

Fill in the blanks.

1. With the ram area switch to the override position the K6 relay will be _____.
2. Positioning the ram area switch to normal will allow the _____ to control the _____.
3. The aircraft airspeed is more than 225 knots the ram air exit door will be _____.

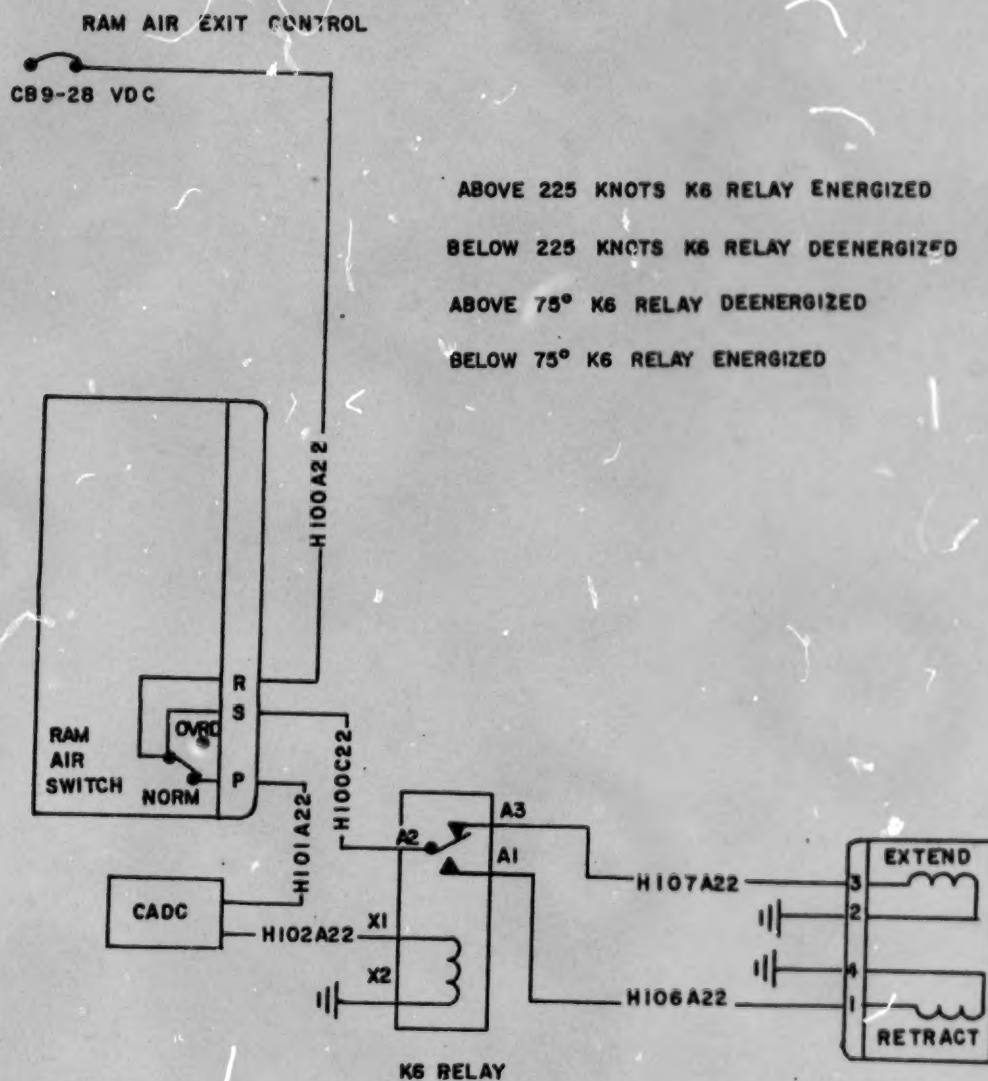


Figure 4.

CORRECT RESPONSES TO FRAME 5: 1. deenergized 2. CADC, K6 relay
3. retracted

Frame 6

The cold air modulating valve controls the air flow to the air-to-water heat exchanger, cooling turbine, and down stream components. Look at figure 5. The valve is positioned by the cabin temperature control system. The valve receives 103V DC that engages a solenoid type clutch. The clutch when energized will connect the valve actuator to the butterfly of the valve. If the DC power is lost, the clutch will deenergize and a spring will move the valve butterfly to the open position. The valve will fail-safe to the open position.

The air-to-water heat exchanger is placed in a water tank. As the engine bleed air goes through the core of the heat exchanger, the heat is transferred through the thin walls of the core to the water. This is the second stage of cooling for the bleed air. The air-to-water heat exchanger is necessary because of the high ram air temperatures which comes from supersonic flight. High ram air temperatures cause inadequate cooling of engine bleed air when only the air-to-air heat exchanger is used.

Fill in the blanks.

1. The cold air modulating valve is controlled by the _____
_____ system.
2. The solenoid clutch connects the _____
to the _____.
3. The air-to-water heat exchanger is mounted inside a
_____.

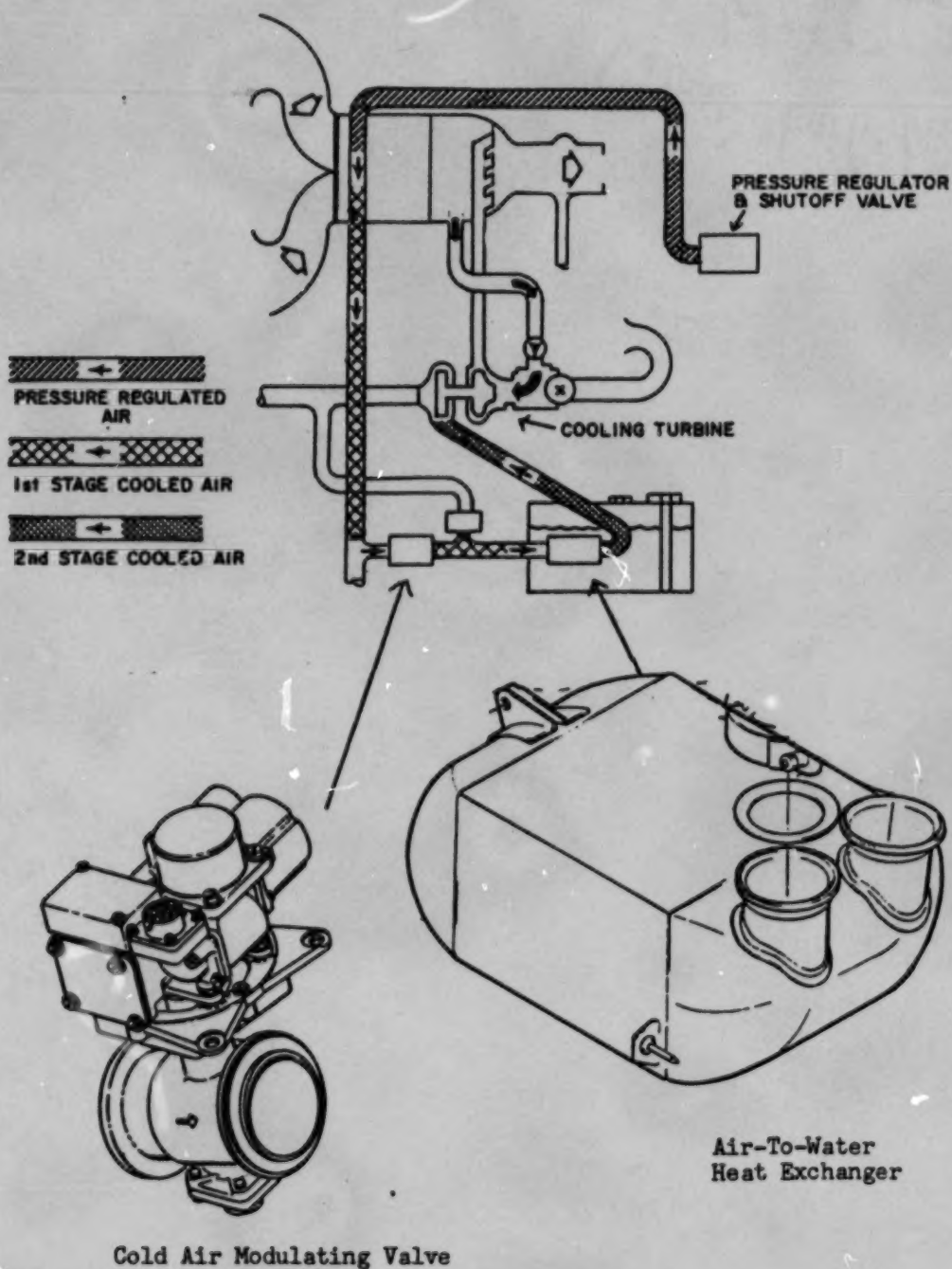


Figure 5.

- CORRECT RESPONSES TO FRAME 6:
1. temperature control
 2. valve actuator, butterfly valve
 3. water tank

Frame 7

The cooling turbine (figure 6) is the last stage of cooling for the engine bleed air. The cooling turbine is a turbine wheel on the same shaft with a compressor wheel. As the air goes through the turbine, it expands and is cooled. At the turbine inlet an over temperature switch protects the turbine from too high temperatures. The compressor wheel is used to place a load on the turbine to keep it from overspeeding. Air flow to the turbine wheel is controlled by the position of the cold air modulating valve. As the cold air modulating valve opens more air is delivered to the turbine wheel. By regulating the setting of the cold air modulating valve, the temperature and flow of air from the turbine can be controlled. The cooling turbine sends cold air to the cabin and electronics compartments. The electronics compartments must always set cold air to keep from overheating. Because of this, the cold air modulating valve will never close all the way. How this is done will be covered later in this text.

Fill in the blanks.

1. The compressor wheel is designed to place a _____ on the turbine wheel to prevent _____.
2. As the cold air modulating valve opens _____ air is delivered to the turbine wheel.
3. By regulating the position of the _____
_____ the temperature of the air from the
_____ can be controlled.

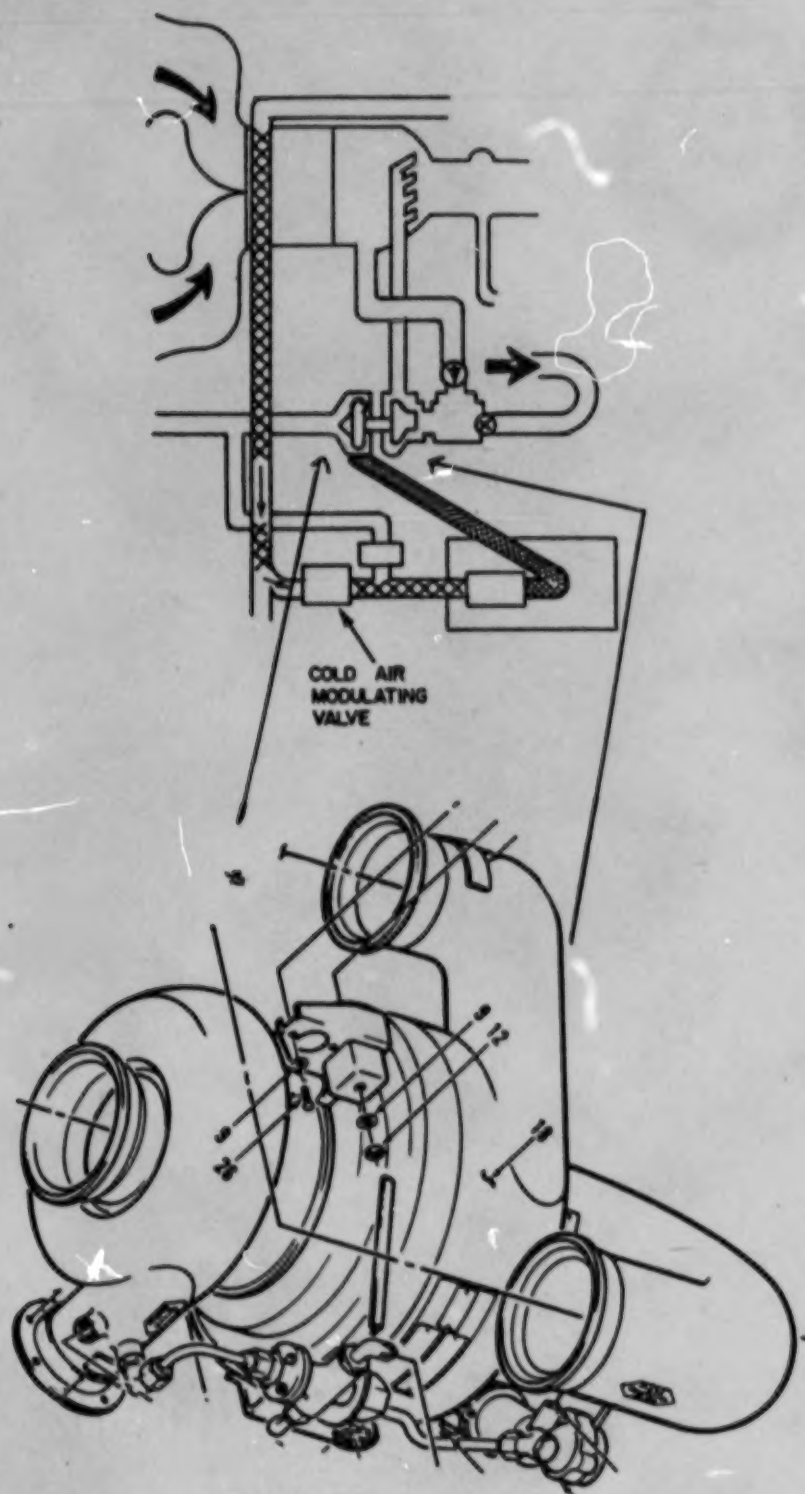


Figure 6.

- CORRECT RESPONSES TO FRAME 7: 1. load, overspeeding
2. more
3. cold air modulating valve, turbine

Frame 8

The turbine will send cold air to the cabin and electronic compartments. A prewhirl valve (figure 7) is attached to the turbine. The valve controls the load that the compressor will place on the turbine. The prewhirl valve is an air operated butterfly valve. Because the load on the turbine is controlled, it can be operated at maximum efficiency at all times. The prewhirl valve has a butterfly valve, valve actuator, control servo, bleed-off valve and a self test actuator. With the prewhirl valve operating in the normal (valve closed) mode, 55 psi air from the service air system goes through the bleed valve. Air flows to the valve actuator and will close the butterfly valve. With the valve in this position low pressure air is tapped from the air-to-air heat exchanger. Air is sent past a check valve, through the compressor wheel to the ejector nozzles. With the prewhirl valve closed, higher turbine speed and more cooling is achieved.

Answer the statements as True (T) or False (F).

- _____ 1. The prewhirl valve controls the load which the compressor will place on the turbine.
- _____ 2. Because the load on the turbine can be controlled, the turbine can operate at maximum efficiency.
- _____ 3. When the prewhirl valve is closed, air is taken from a ram air inlet.

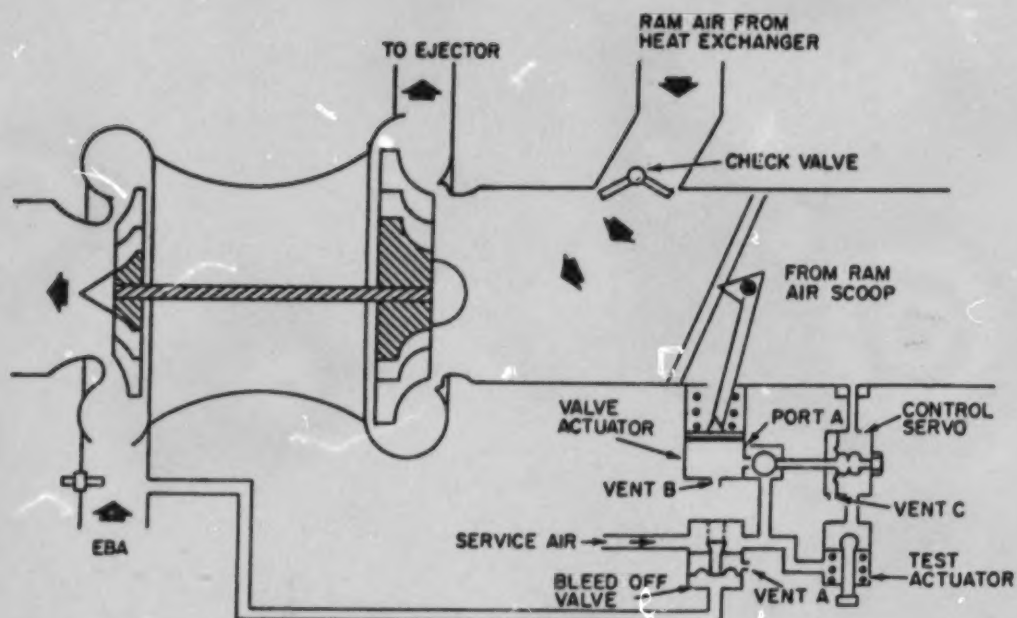
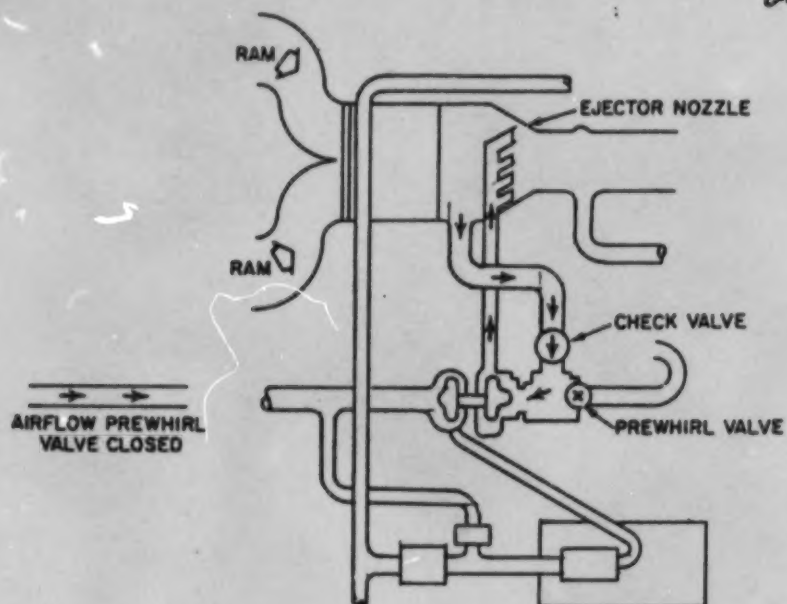


Figure 7.

CORRECT RESPONSES TO FRAME 8: 1. T 2. T 3. F

Frame 9

At altitudes above 17,500 feet air flow to the air-to-air heat exchanger is not dense enough to stop turbine overspeed. In this case the control servo will close port A in the valve actuator (figure 8). Pressure in the actuator will bleed out of vent B and cause the butterfly valve to open. Air of higher pressure and density can be taken from the ram air inlet. Ram air goes in the prewhirl valve and will close off the check valve to the air-to-air heat exchanger. The ram air will pass through the compressor wheel to the ejector nozzles.

The prewhirl valve may also select a mixture of ram air and heat exchanger exhaust air (figure 9). If turbine inlet pressure becomes high, pressure in the line from the turbine inlet to the bleed-off valve becomes high. Air pressure from the turbine inlet is felt on the bottom side of the bleed-off valve diaphragm. Air pressure will push the diaphragm up and open the bleed-off valve and lower service air pressure. The lower service air pressure will allow the valve actuator to move down and the butterfly valve will move toward open. Pressing the test actuator button will apply service air to the control servodiaphragm. This will close off port A and the spring in the valve actuator will open the butterfly valve.

Fill in the blanks.

1. At altitudes above 17,500 feet, air flow to the air-to-air heat exchanger is not _____ to prevent _____.
2. The prewhirl valve cannot select a mixture of ram air and heat exchanger exhaust air. (T or F)
3. Pressing the self test button will cause the butterfly valve to _____.

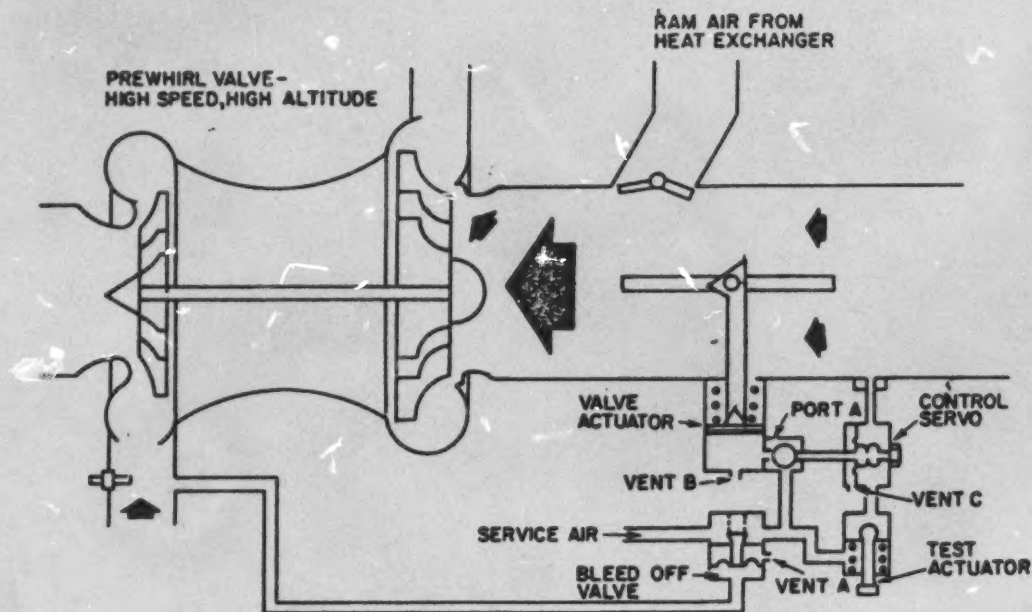


Figure 8.

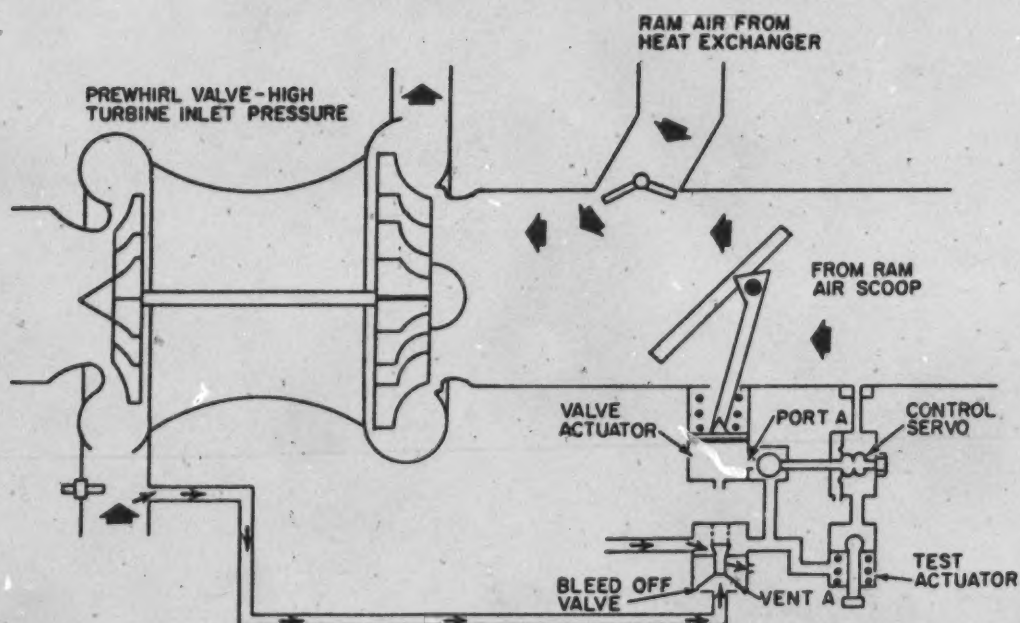


Figure 9.

- CORRECT RESPONSES TO FRAME 9: 1. dense enough, turbine overspeed
2. F
3. open

Frame 10

As the air goes out of the turbine discharge port, it goes through an ice screen. The purpose of the ice screen (figure 10) is to collect particles of ice that were made by the cooling process. A build-up in ice on the screen will cause turbine discharge pressure and temperature to rise. This will cause the ice to melt and keep the ducting open. Downstream of the ice screen is the turbine discharge pressure relief valve. This valve is made to maintain a ratio between duct pressure and outside air pressure. Should the duct pressure get too high, as a result of a block in the downstream ducting, the relief valve will open and relieve pressure.

Fill in the blanks.

1. The purpose of the ice screen is to collect particles of ice that were made by the _____.

2. If the duct pressure is too high, the _____
_____ will _____.

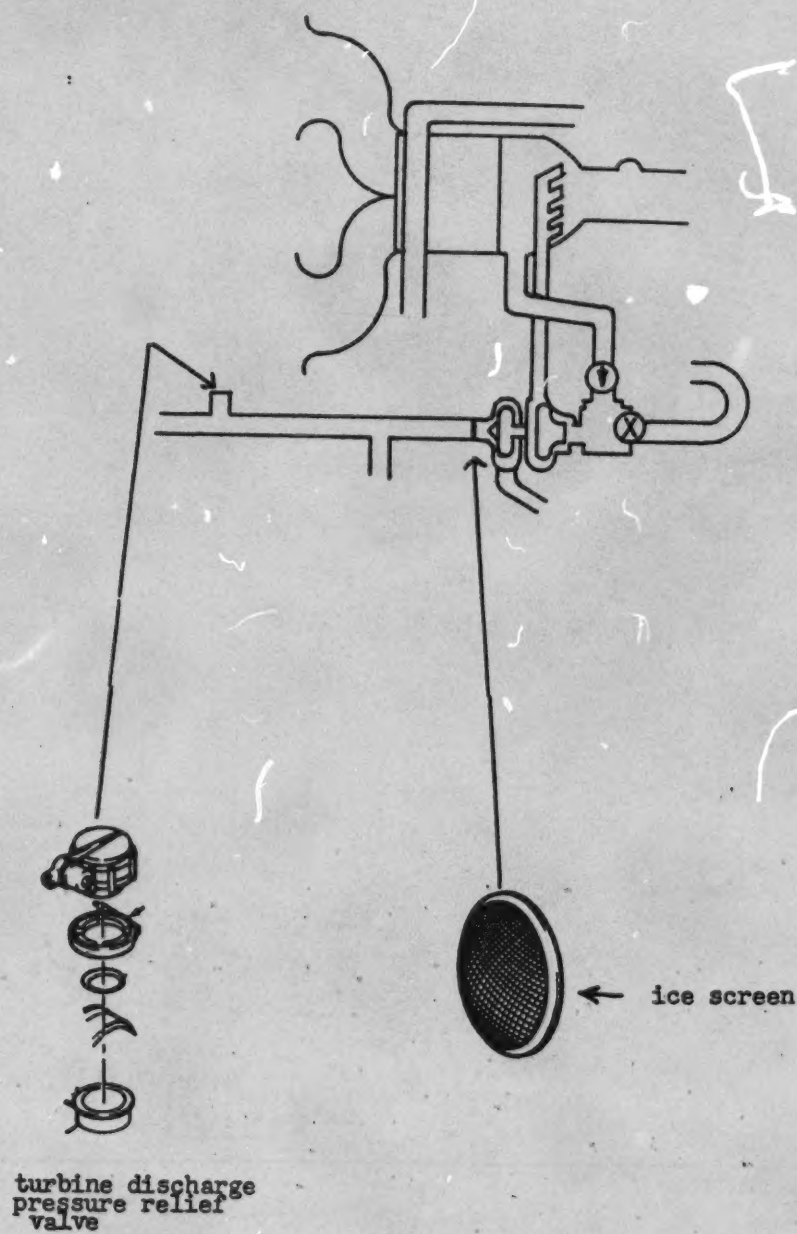


Figure 10.

- CORRECT RESPONSES TO FRAME 10: 1. cooling process
2. relief valve, open

Frame 11

After the air flows out of the cooling turbine to the cabin and electronics the air must then pass through a water separator. The water separator will remove close to 80% of the moisture in the air. A close up view of the water separator is shown in figure 11. The water separator is made of a support, coalescer bag, water collector and a bypass valve. Operation of this water separator is the same as the water separators you have studied.

Fill in the blank spaces.

1. The water separator will remove close to _____ of the moisture in the air.

2238

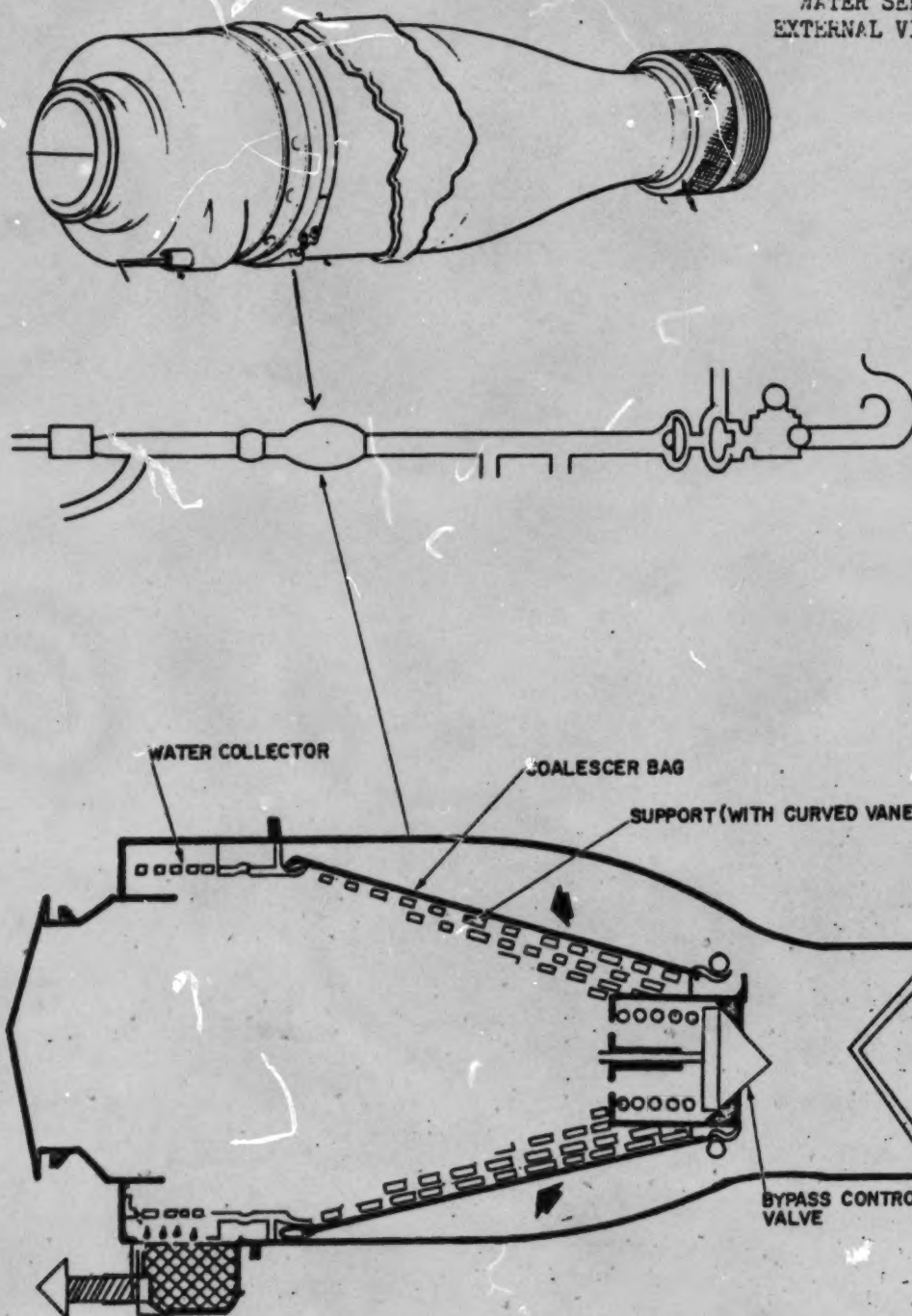
WATER SEPARATOR
EXTERNAL VIEW

Figure 11.

Frame 12

Figure 12 shows the air flow and electrical diagram of the turbine bypass system. This system will increase air flow to the cabin and electronics equipment when the aircraft is at low engine power. The turbine bypass valve will open to mix cooled air from the air-to-air heat exchanger with turbine discharge air for more air flow. Two conditions must exist for the turbine bypass valve to open: (1) aircraft altitude must be less than 10,000 feet; (2) bleed air must be less than 30 psi. The electrical circuit shows the positions that the K8 relay and the low pressure switch must be in for the turbine bypass valve to open. The relay is controlled by the CADC. Below 10,000 feet the CADC will deenergize the relay. The low pressure switch is in the bleed air duct. If bleed air pressure falls to less than 30 psi the switch will close a circuit between contacts 3 and 2. This will send 28V DC from CB 5 to the turbine bypass valve. If the aircraft is above 10,000 feet the CADC will energize relay K8. Relay K8 will open the circuit to the turbine bypass valve. If the bleed air pressure is more than 30 psi the low pressure switch will open the circuit to the bypass valve.

Fill in the blanks.

1. The turbine bypass system increases air flow to the cabin and electronics equipment when the aircraft is at _____ engine power.
2. There must be _____ conditions before the turbine bypass valve will open.
3. If aircraft altitude is more than 10,000 feet and bleed air pressure is less than 30 psi the turbine bypass valve will _____.

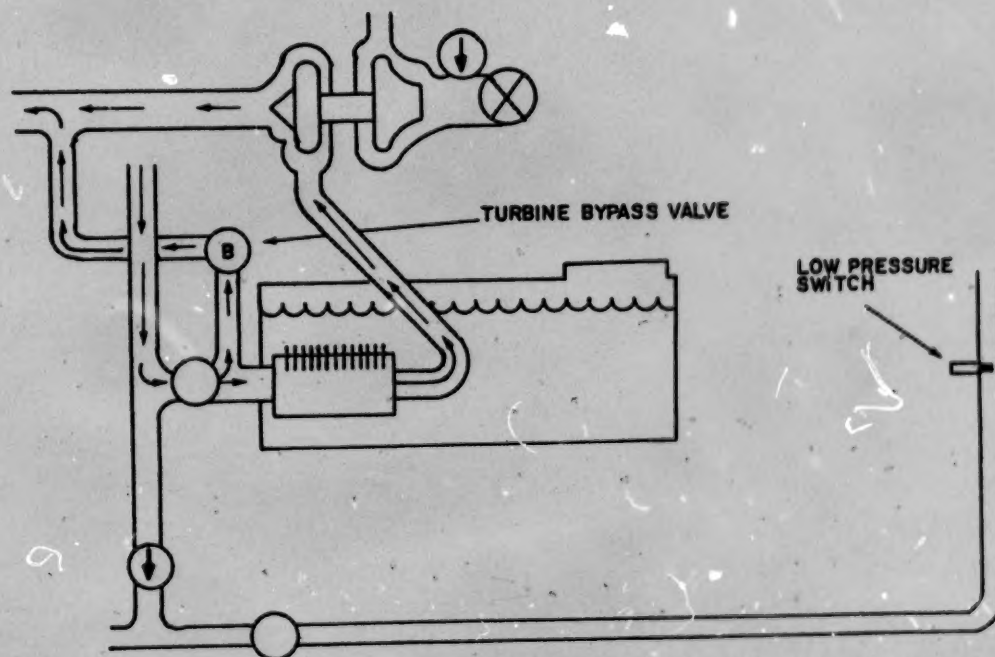
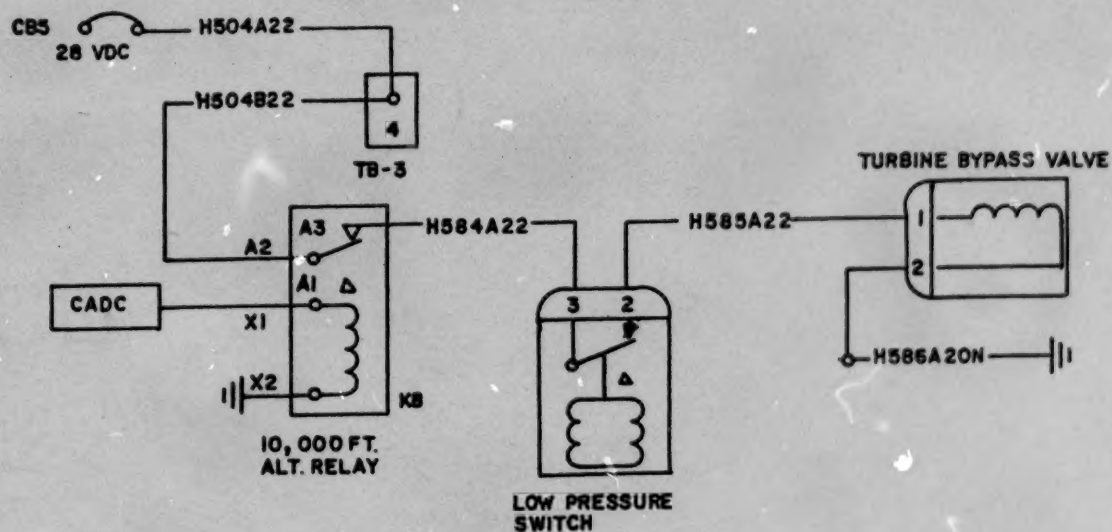


Figure 12.

- CORRECT RESPONSES TO FRAME 12:
1. low
 2. two
 3. close

Frame 13

Look at figure 13. The low limit control is made of the low limit temperature control valve and the low limit temperature control sensor. The sensor is downstream of the water separator. It senses the temperature of the air that flows out of the water separator. The low limit control valve is in the duct that connects the cold and hot air systems. This valve is normally in the closed position. When the low limit sensor senses temperature low enough to cause the water separator to freeze, it will, through a pneumatic line, cause the low limit control valve to open. Opening the low limit control valve will allow air from the hot air system to mix with the cold air from the cooling turbine. This mixture of air will keep the water separator from freezing.

Answer the statements as True (T) or False (F).

- _____ 1. The low limit control keeps the water separator from freezing.
- _____ 2. The low limit control valve is normally in the open position.

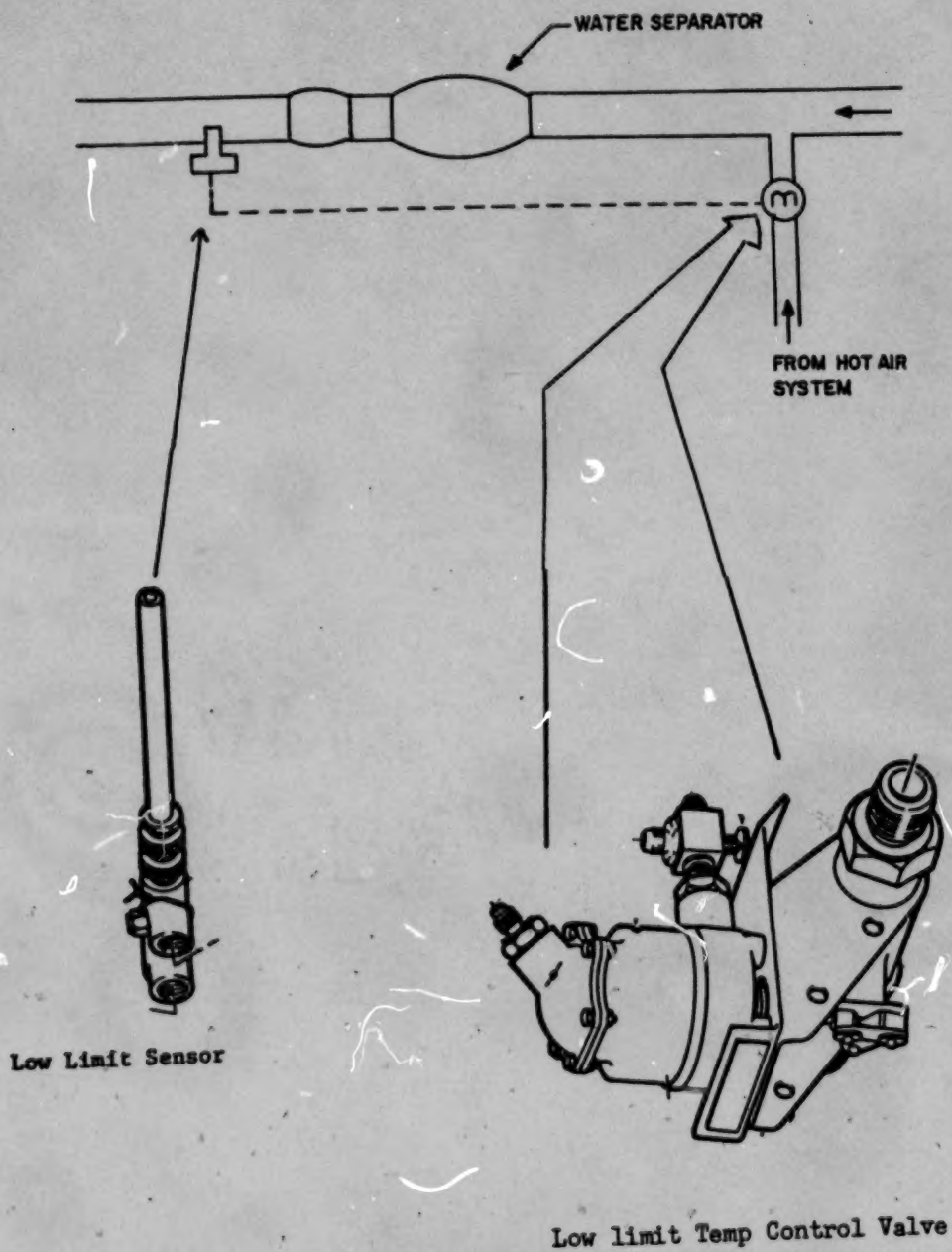


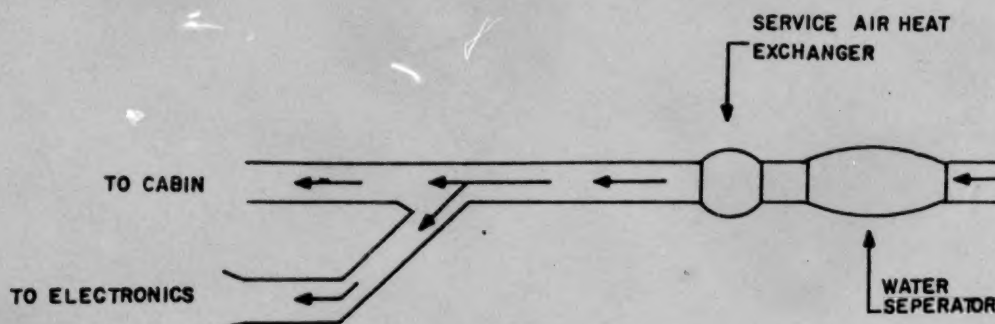
Figure 13.

2243

CORRECT RESPONSES TO FRAME 13: 1. T 2. F

Frame 14

After the air flows from the water separator, air flows through the service air heat exchanger (figure 14). Downstream of the service heat exchanger, the cold air flows to reach a point where there are two paths for air flow. One path goes to the electronics equipment. The other goes to the cabin. The next component in the cold air system will effect the hot air system. Due to this, we will go through the hot air system first, then go through the rest of the cold air system.



Fill in the blanks.

1. Air flows through the water separator to the _____

_____.

CORRECT RESPONSES TO FRAME 14: service air heat exchanger

Frame 15

For the following questions, read the part name shown on the left side of the page. In the space, place the letter from the list on the right side of the page that matches the function of that part.

- | | |
|--|---|
| _____ 1. Pressure regulating and shutoff valve | A. Increases effectiveness of the air-to-air heat exchanger. |
| _____ 2. Low limit control | B. Stops freezing of the water separator. |
| _____ 3. CADC | C. Controls compressor load on the cooling turbine. |
| _____ 4. Preshirl valve | D. Controls the amount of air flow through the cooling turbine. |
| _____ 5. Cold air modulating valve | E. Sends air to the ejector nozzles. |
| _____ 6. Ejector nozzles | F. Controls the position of the ram air exit door. |
| _____ 7. Compressor | G. Regulates at 165 psi. |

CORRECT RESPONSES TO FRAME 15: 1. G 2. B 3. F 4. C
5. D 6. A 7. E

Frame 16

The hot air system sends air to the low limit temperature control valve, windshield rain removal and the hot air modulating valve. The hot air comes from the main bleed air manifold. It is sent through a duct to the hot air temperature control valve (figure 15). The hot air valve works with the hot air temperature sensor and hot air stabilization controller. These parts control hot air to 390°F. The valve does this by controlling the amount of EBA that is mixed with partially cooled air. The cooled air comes from the air-to-air heat exchanger. The hot air temperature control valve is controlled by changes in the temperature sensed by the hot air temperature sensor. A check valve is in the duct from the air-to-air heat exchanger. The check valve stops a reverse flow of air into the cold air system.

Answer statements as True (T) or False (F).

- _____ 1. The hot air temperature control valve moves in response to changes in temperature felt by the hot air temperature sensor.
- _____ 2. A check valve is in the duct from the air-to-air heat exchanger.
- _____ 3. Temperature control is obtained by mixing partially cooled air from the air-to-air heat exchanger with air from the hot air temperature control valve.

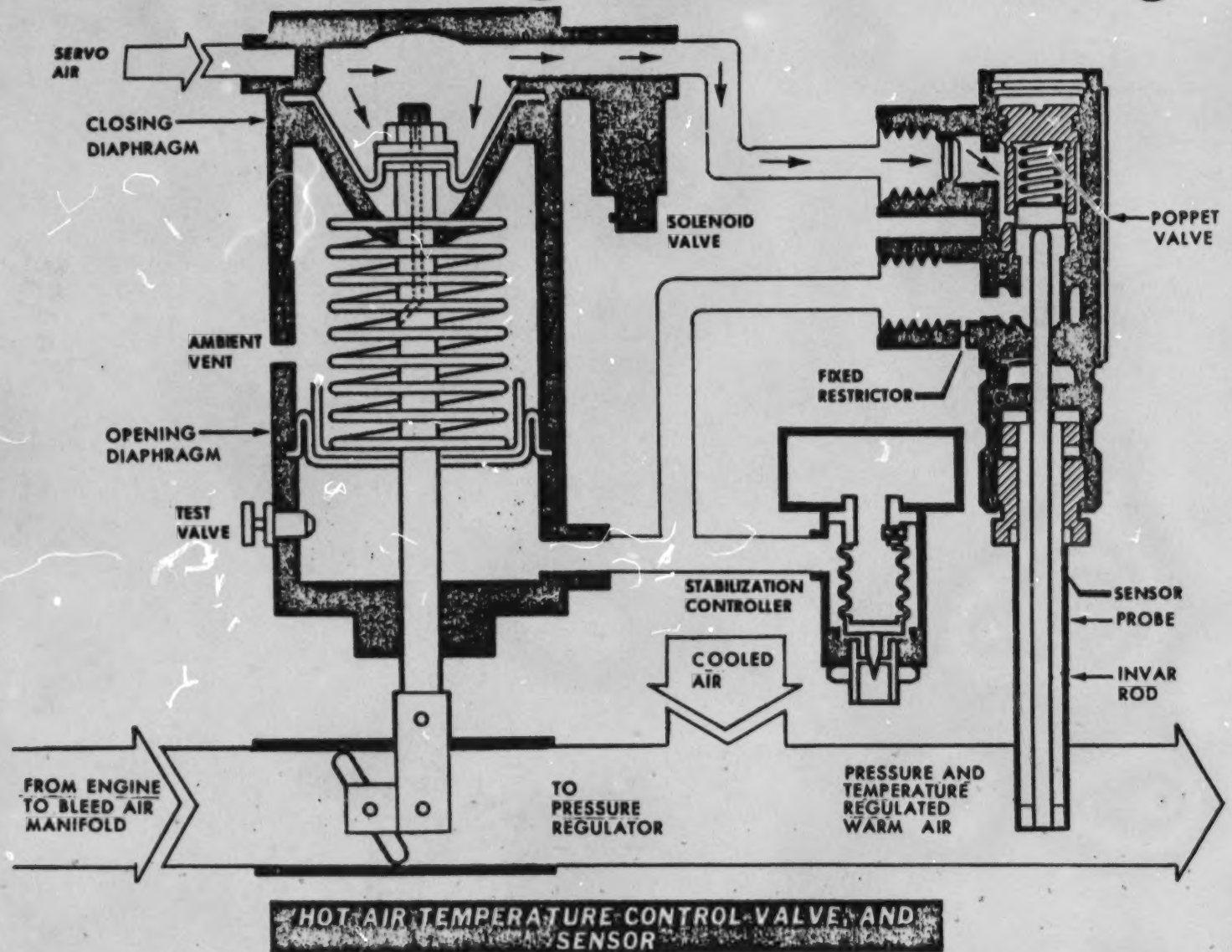


Figure 15.

2247

CORRECT RESPONSES TO FRAME 16: 1. T 2. T 3. T

Frame 17

The hot air pressure regulating valve (figure 16) is in the line that runs between the hot air temperature control valve and the hot air temperature sensor. It is made up of two regulating parts. One is the primary regulator that keeps system pressure at 45 psi. The other part is the secondary regulator. It takes over if the primary fails and will keep system pressure at 65 psi. There is a red over-pressure indicator on the regulator that will extend to show that the primary control has failed. There is also a test button on the regulator. It is used to ground check the secondary control to make sure it works right.

Fill in the blanks.

1. The hot air pressure regulating valve is in the line between the _____ and the _____.
2. The hot air pressure regulating valve has _____ separate regulating parts.
3. Failure of the primary regulator can be known by observing the _____.

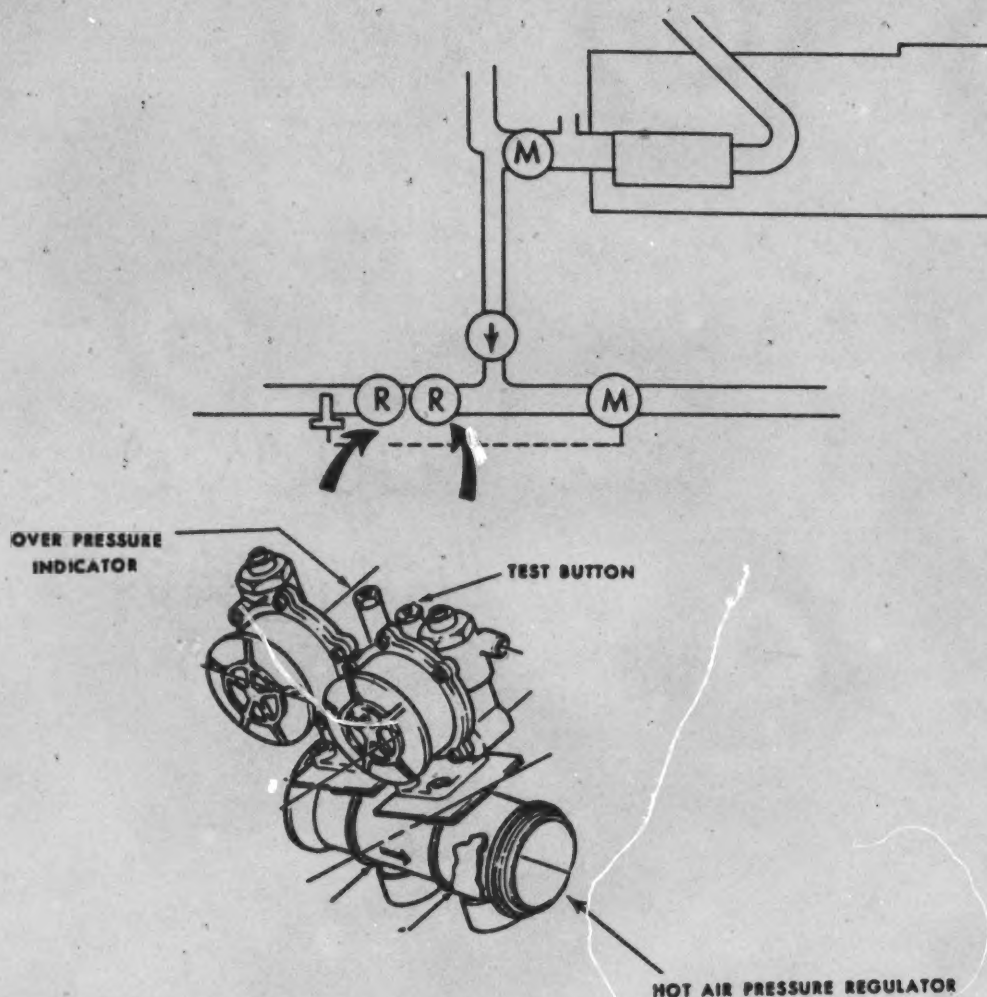


Figure 16.

2249

- CORRECT RESPONSES TO FRAME 17:
1. hot air temperature control valve,
hot air temperature sensor
 2. two
 3. red over-pressure indicator

Frame 18

Look at figure 17. As air flows through the pressure regulating valve, it comes to a point where there are two paths for air to flow. One path goes to the windshield clearing system. The other path routes hot air to the cold air system through the hot air modulating valve. This valve controls hot air that flows to the cold air system for cabin temperature control. Find on the diagram, where the hot air duct joins the cold air duct. Note this is after cold air is taken for electronics cooling. This means that only cold air flows to the electronics equipment.

Answer the statements as True (T) or False (F).

- _____ 1. The hot air modulating valve controls the amount of hot air supplied to the cold air system for cabin air conditioning.
- _____ 2. The hot air modulating valve is mounted in a duct between the hot and cold air system.
- _____ 3. The cabin receives only cold air from the cabin air conditioning system.

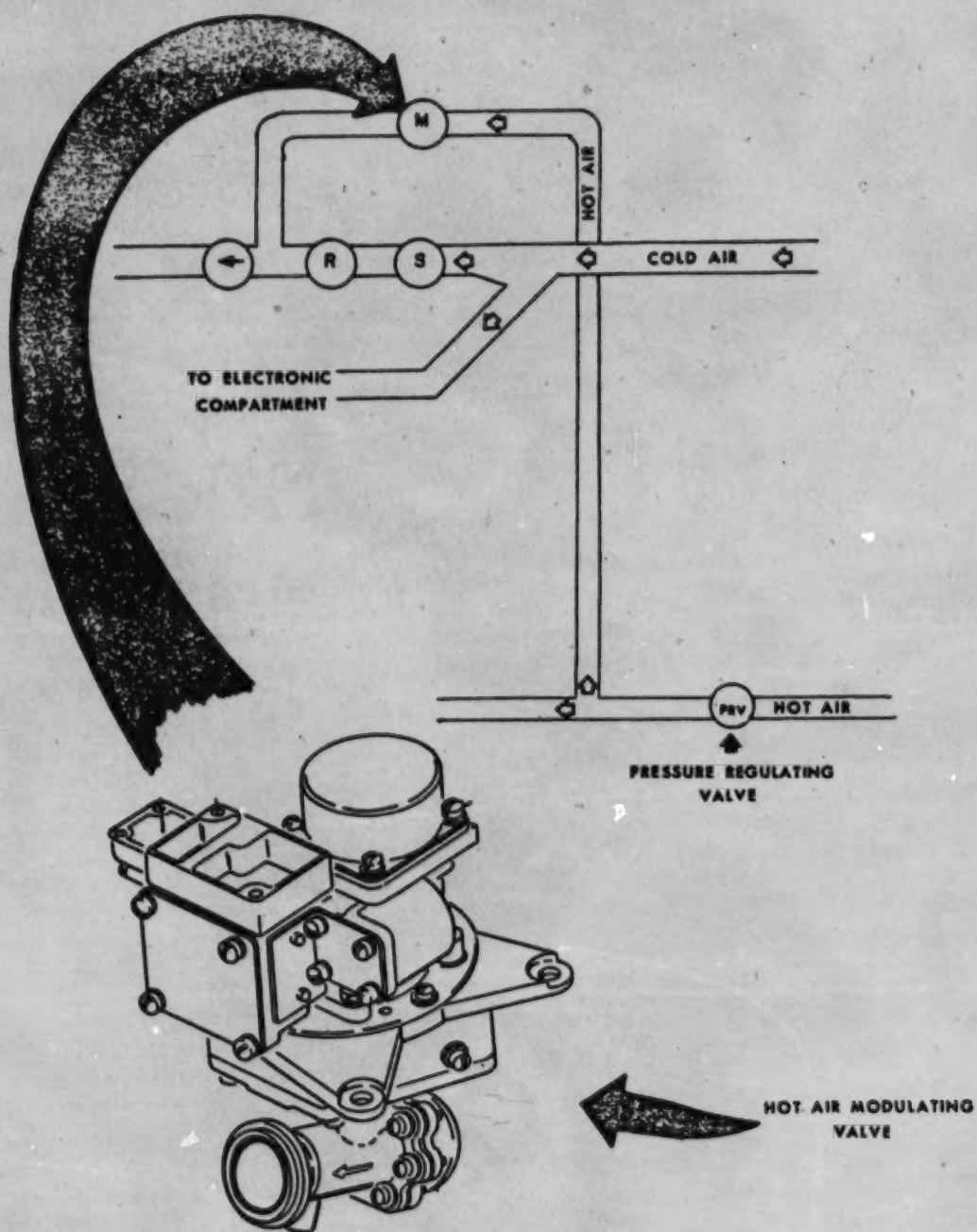


Figure 17.

CORRECT RESPONSES TO FRAME 18: 1. T 2. T 3. F

Frame 19

Look at figure 18. The hot air modulating valve with the cold air modulating valve control cabin temperature. Movement of the valve is by 115V AC from the temperature control circuit. 115V AC is to the open or closed sides of the valve motor. The valve motor is linked to the valve butterfly through a clutch. The clutch gets 103V DC from the temperature control box. Should the 103V DC be lost, the valve will be moved to the closed position by a spring.

Fill in the blanks.

1. The valve motor is linked to the valve butterfly through a

_____.

2. If the 103V DC power is lost, the valve will be moved

_____ by a _____.

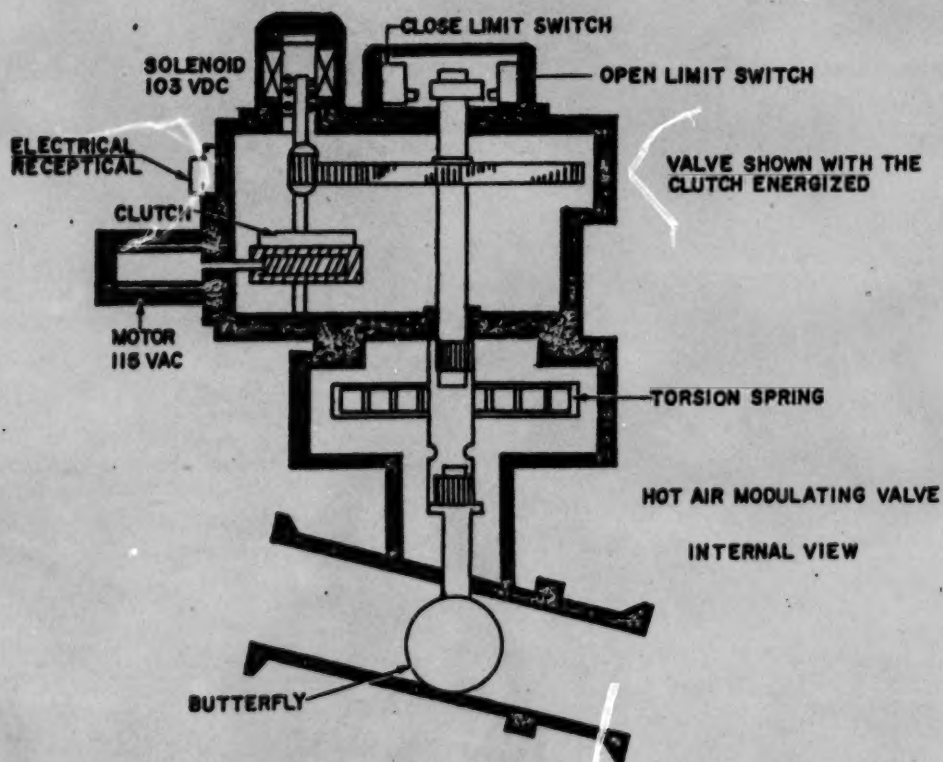
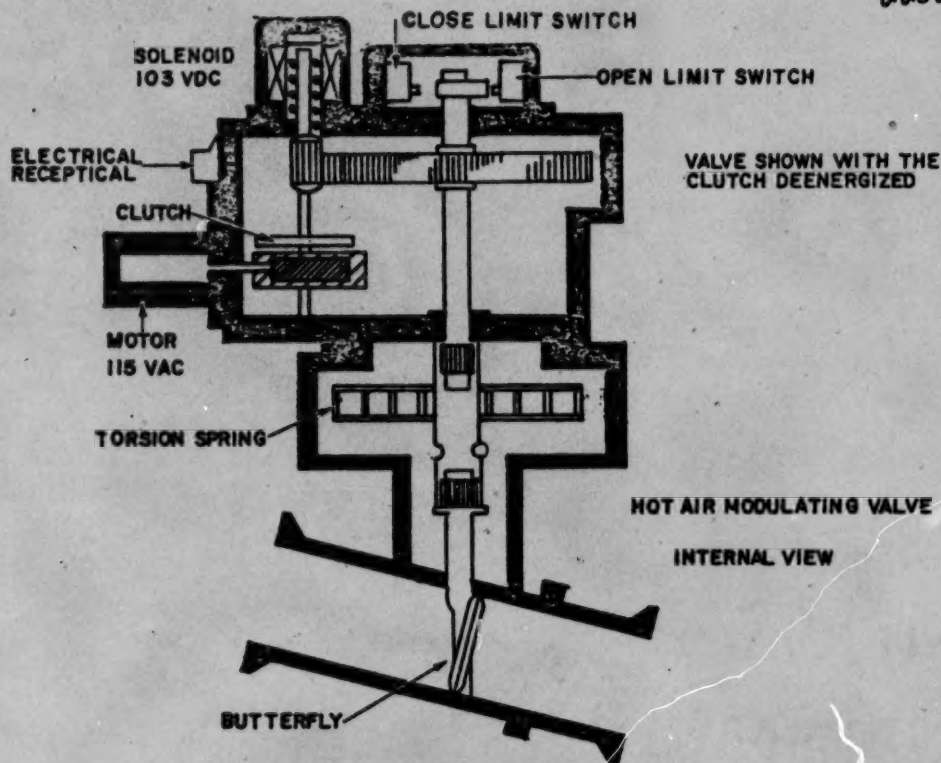


Figure 18.

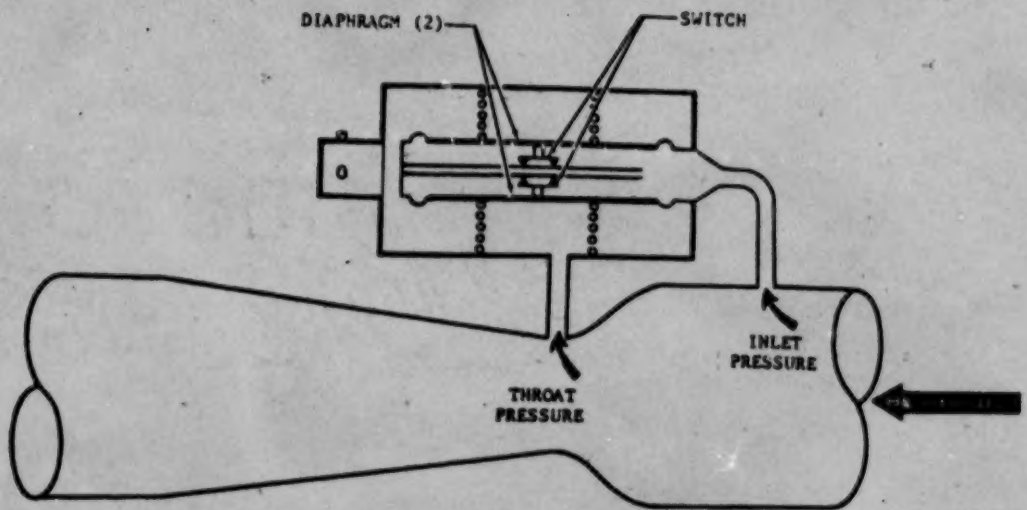
CORRECT RESPONSES TO FRAME 19: 1. clutch
2. closed, torsion spring

Frame 20

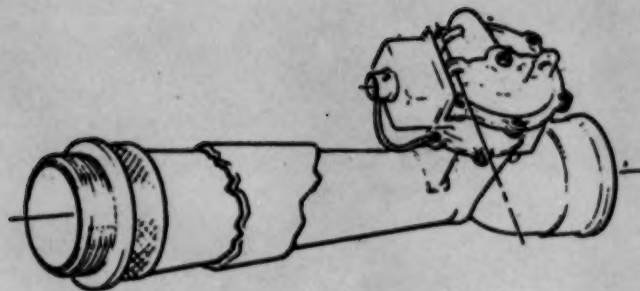
Cabin temperature is controlled by both the hot and cold air modulating valves. The minimum flow pressure switch (figure 19) will keep the cold air valve from going to full closed. This sends a constant flow of cold air to the cabin and electronics equipment. The minimum flow pressure switch is made of two diaphragms and an air flow venturi. The switch is moved by the diaphragms when there is a change in air flow through the air flow venturi. The switch will send electrical current to either the hot or cold air modulating valve. The minimum flow pressure switch is downstream of the moisture separator. (See foldout 1)

Fill in blanks provided.

1. The minimum flow pressure switch will keep the _____
_____ from going to full _____.
2. The switch is moved by _____.
3. Temperature control for the cabin is done by movement of the
_____ and _____ air modulating valves.



MINIMUM FLOW PRESSURE SWITCH
INTERNAL VIEW



MINIMUM FLOW PRESSURE SWITCH
EXTERNAL VIEW

Figure 19.

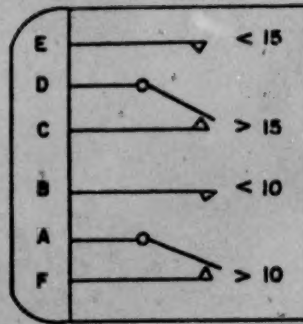
CORRECT RESPONSES TO FRAME 20: 1. cold air modulating valve, closed
2. diaphragms
3. hot, cold

Frame 21

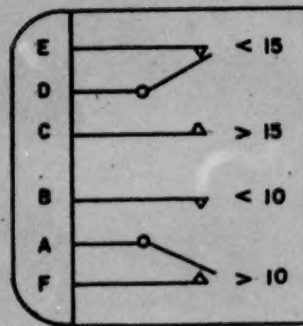
Symbols are used in this system to show an approximate temperature or rate of air flow. Most of the time these symbols will be found on diagrams and control panels. The symbol > means "more than" and < means "less than". You should learn these and try your best to remember them. Look at figure 20. It shows the minimum flow pressure switch that has two sets of contacts. The diagram shows the switch in different positions under various air flow conditions. The symbols at the side of each set of contacts show that the air flow is more or less than 10 or 15 pounds per minute (ppm).

Answer statements True (T) or False (F).

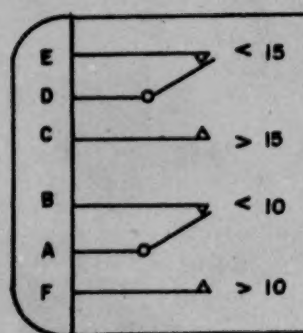
- _____ 1. The symbol > can be used to show more than a given temperature.
- _____ 2. The symbol < can be used to show less than a given air flow.



MINIMUM FLOW PRESSURE
SWITCH MORE THAN 15 PPM



MINIMUM FLOW PRESSURE
SWITCH LESS THAN 15 PPM
OR MORE THAN 10 PPM



MINIMUM FLOW PRESSURE
SWITCH LESS THAN 10 PPM

Figure 20.

CORRECT RESPONSES TO FRAME 21: 1. T 2. T

Frame 22

Figure 21 shows an electrical diagram of the hot and cold modulating valves, minimum flow pressure switch and one electrical connector of the temperature control box (P13). In the next few frames, you will use this diagram to trace current flow. Look at connector (P13), note that 103V DC is sent through pins E, B D-C and to the hot and cold air modulating valve clutches. A cooling signal from the temperature control box is sent through pin R; a heating signal through pin S.

On some of the connectors in the wiring diagrams the letters are underlined. This means that the pin on the electrical connector will be marked with a LOWER case letter. S on the wiring diagram would be a lower case s on the connector trainer. (S = s).

Answer the statements True as (T) or False (F).

- _____ 1. 103V DC is sent through pins A B C and D to the hot and cold air modulating valve clutches.
- _____ 2. A cooling signal from the temperature control box is applied through pin R and a heating signal through pin S.

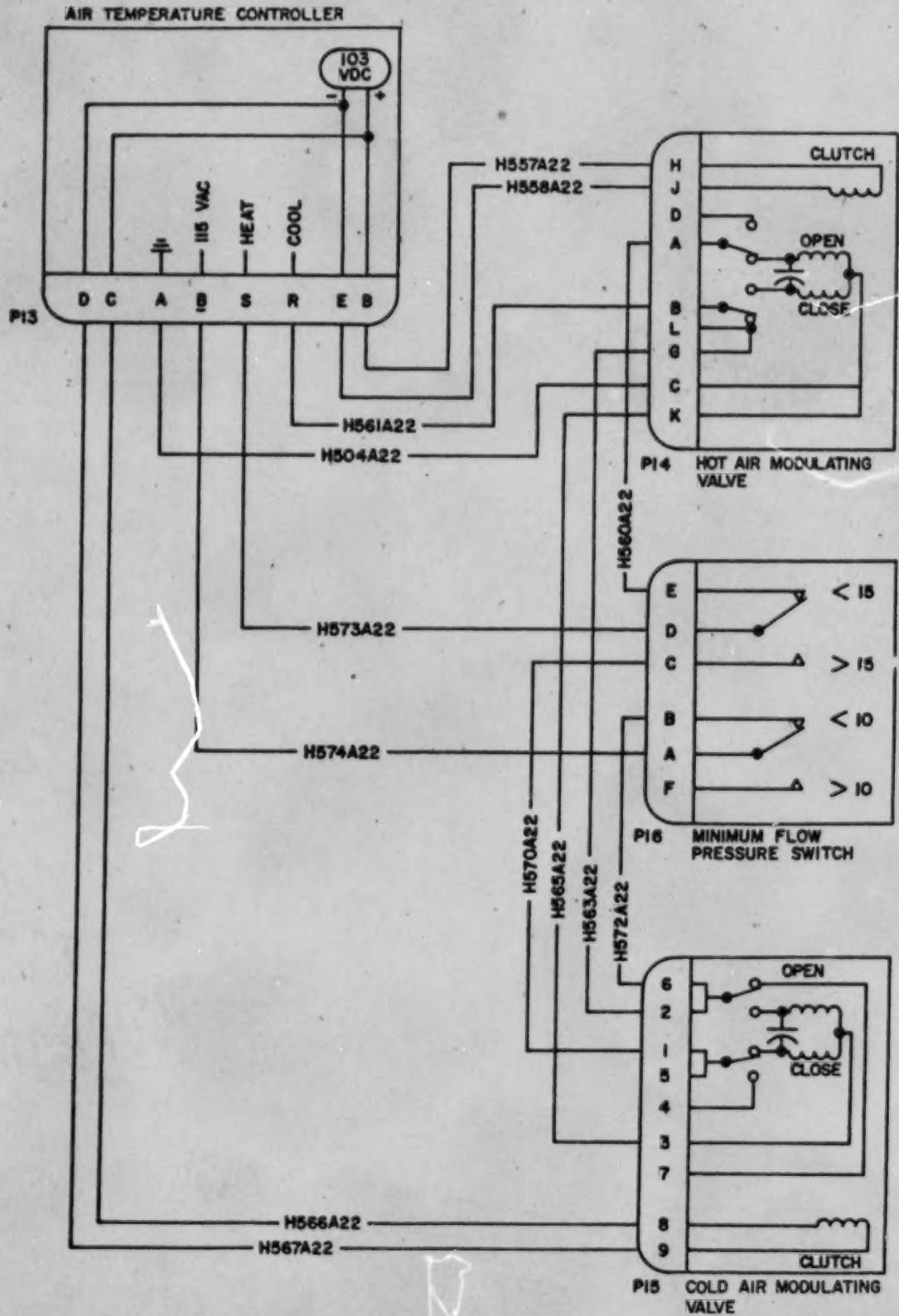


Figure 21. 421
41

Frame 23

Look at figure 22. The temperature control circuit is asking for cold. Use a blue pencil to trace this circuit. Start at pin R of the connector (Pl3) and trace over wire #H561A22 to pin B of the hot air modulating valve. This will cause the hot air modulating valve to move to the closed position. The valve closed the limit switch then completes a circuit from pin B to pin G. From pin G potential is through wire #563A22 to pin 2 of the cold air modulating valve. The cold air valve will then move to the open position. Notice that with a cooling signal from the temperature control circuit current does not pass through the minimum flow pressure switch. This is to make sure that with the cold air modulating valve moving open there is no danger of closing off all the cold air flow.

Fill in the blanks.

1. The temperature control circuit demanding cold will cause the hot air modulating valve to _____.
2. A cooling signal from the temperature control circuit _____ pass through the minimum flow pressure switch.

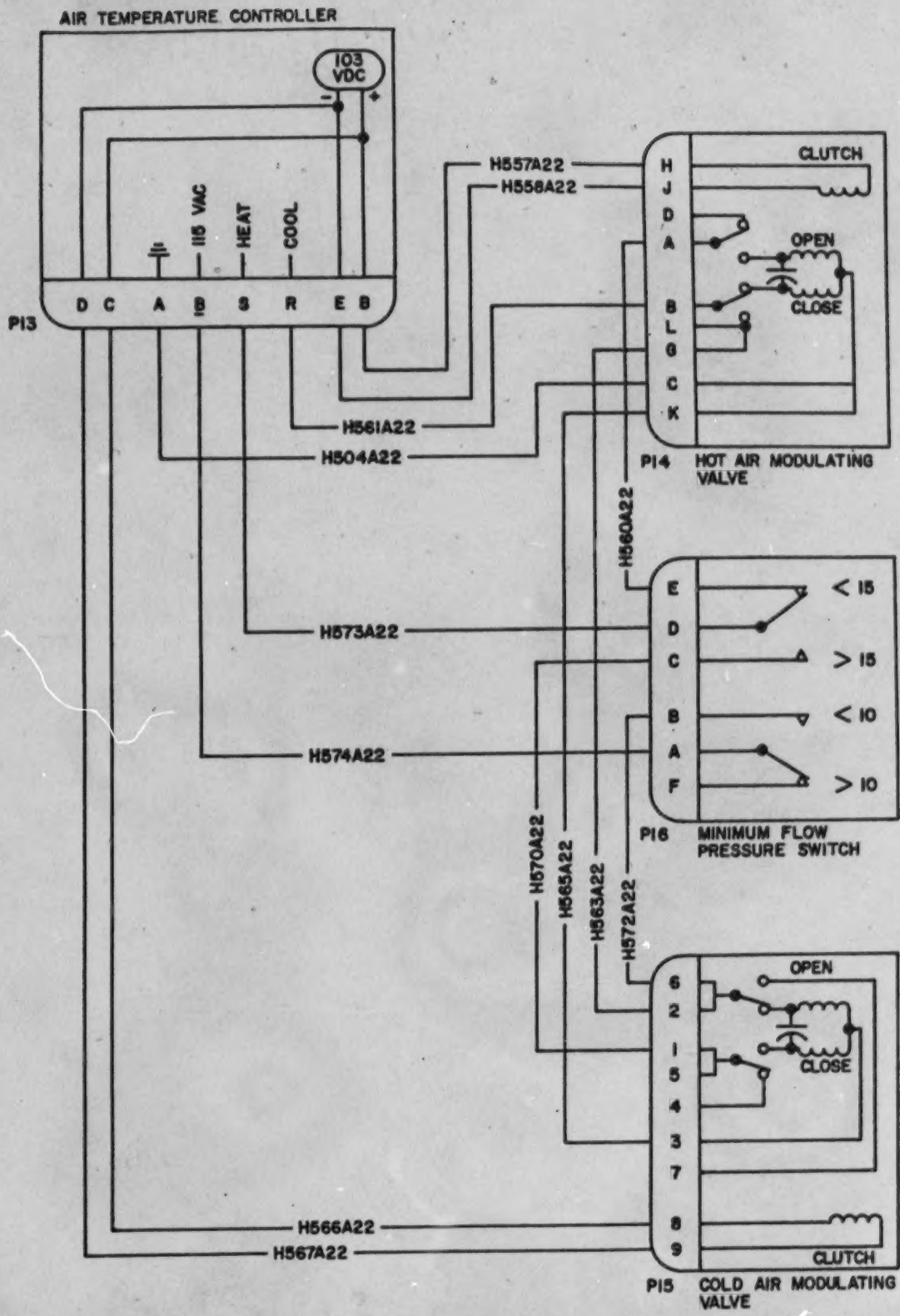


Figure 22.
43

CORRECT RESPONSES TO FRAME 23: 1. close
2. does not

Frame 24

Look at figure 23. As it was said in the last frame, a cooling signal from the temperature control circuits does not pass through the minimum flow pressure switch. However, a heating signal from the temperature control circuits must always pass through the switch. With air flow above 15 ppm and a heating signal asked for by the temperature control system, trace this circuit with a red pencil. Power is at pin 5 of connector P13. Current flows over wire #H573A22 to pin D of the minimum flow pressure switch. Since air flow is above 15 ppm, the contacts make a circuit between pins D and C of the pressure switch. Current will flow from pin C through wire #H570A22 to pin #1 of the cold air modulating valve. The cold air valve will start to move toward closed. The cold air modulating valve is upstream of the minimum flow pressure switch. Because of the positions of these parts in the system, moving the cold air modulating valve toward closed will decrease air flow through the minimum flow pressure switch. Look at foldout 1.

Fill in the blanks.

1. A heating signal from the temperature control circuit

_____ pass through the minimum flow pressure switch.

2. Moving the cold air modulating valve towards the closed

position will _____ air flow through the minimum flow pressure switch.

2262

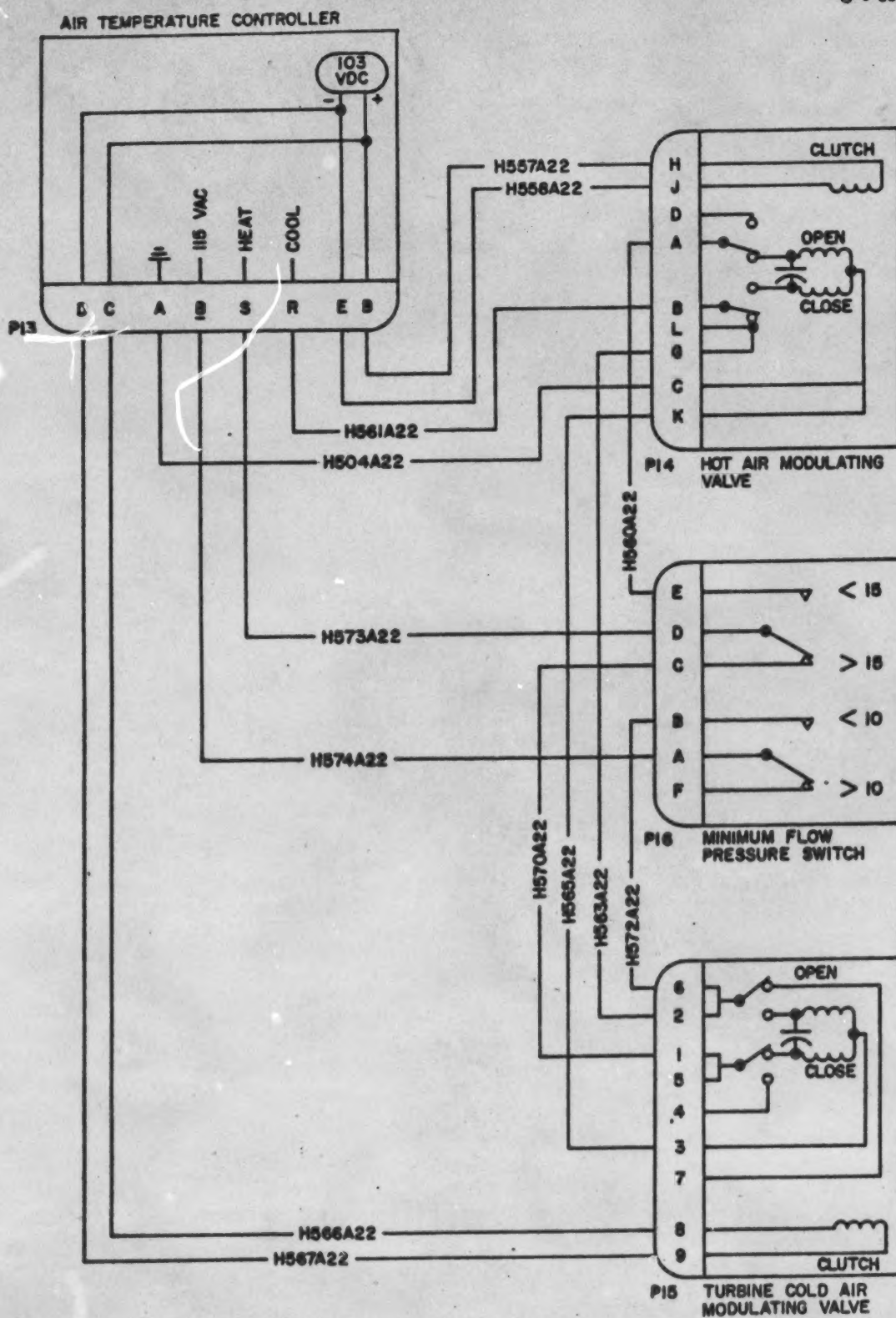


Figure 23. 425
45

2263

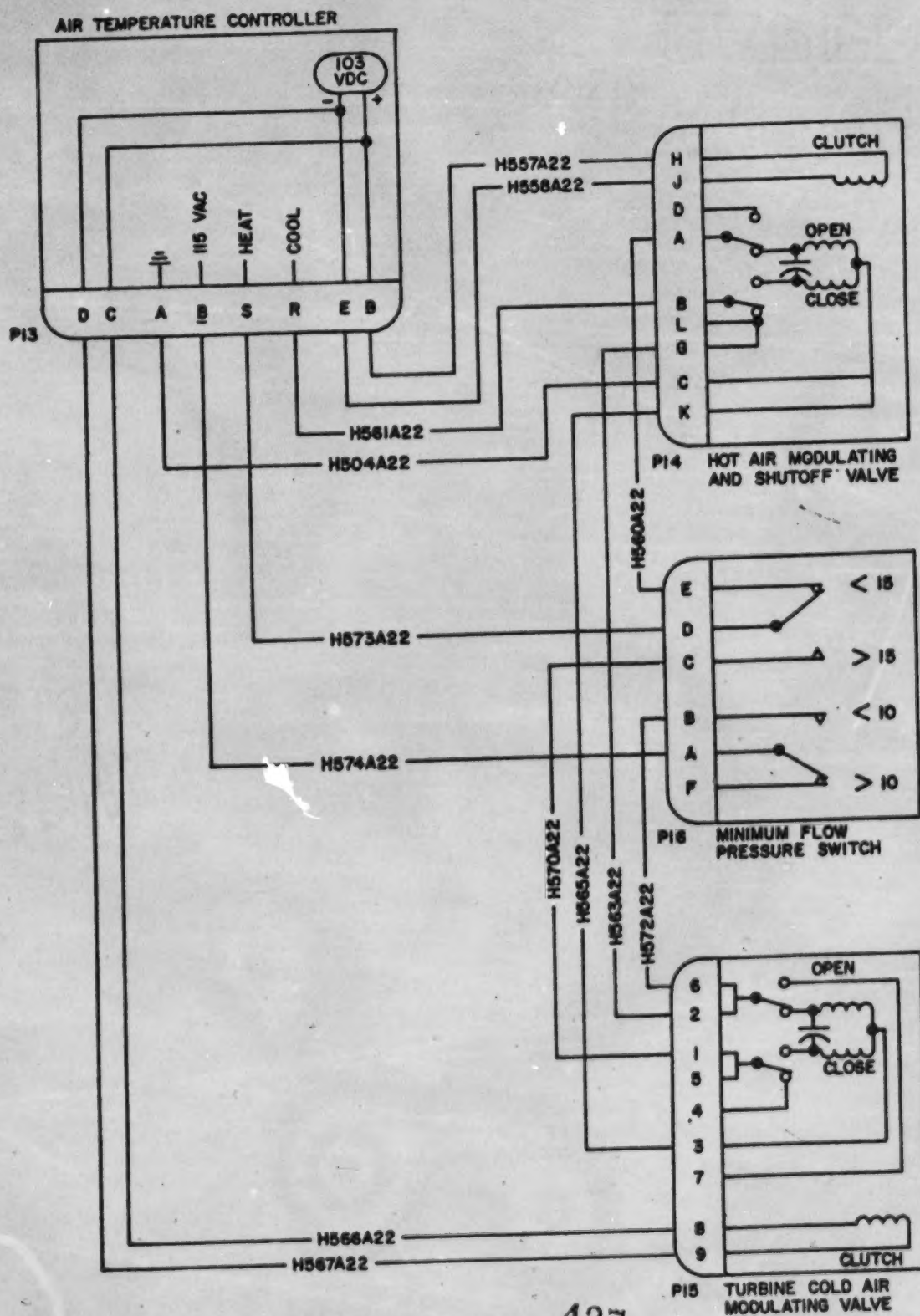
- CORRECT RESPONSES TO FRAME 24: 1. must always
2. decrease

Frame 25

Frame 24 showed a heating signal and an air flow above 15 ppm. As the cold air modulating valve starts to move closed, air flow through the minimum flow pressure switch will drop to below 15 ppm. Use a green pencil to trace this circuit (figure 24). Start at pin S of connector P13, trace the flow of current from pin S through wire #H573A22 to pin D of the minimum flow pressure switch. In frame 24, air flow through the minimum flow pressure switch was above 15 ppm. A circuit was made through pins D and C to the cold air modulating valve. As the cold air modulating valve starts to move closed, air flow through the pressure switch drops to less than 15 ppm. The air flow pressure switch makes a circuit between pins D and E. Trace voltage from point E through wire #H560A22 to pin A of the hot air modulating valve. This will close the valve to move toward the open position, maintaining 15 ppm.

Fill in the blank spaces.

1. As the cold air modulating valve starts to close, the air flow at the minimum flow pressure switch will be _____ 15 ppm.
2. After the minimum flow pressure switch drops, the flow of air below 15 ppm the _____ valve will move toward the _____ position.



427

Figure 24.
47

2265

- CORRECT RESPONSES TO FRAME 25: 1. below
2. hot air modulating, open

Frame 26

There will be no change in the minimum flow pressure switch position while air flow is between 10 ppm to 15 ppm. In this range temperature is changed by movement of the hot air modulating valve. The valve will move when the temperature control system asks for hot air. If air flow drops to below 10 ppm, there is danger of a low flow of air flow to the cabin and electronics equipment. The minimum flow pressure switch will feel the low air flow through the air flow venturi. The low air flow will change the switch position. Use an orange pencil, trace this circuit (figure 25). Pin B (remember B = b) of connector P13 gets 115V AC from the control box circuits. Trace from pin B and wire #H574A22 to pin A of the minimum flow pressure switch. When air flow is below 10 ppm, a circuit is made from pin A to pin B of the pressure switch. Current flows from pin B over wire #H572A22 to pin 6 of the cold air modulating valve. The cold air modulating valve moves open to cause an increase in air flow.

Fill in the blanks.

1. If the flow at the minimum flow pressure switch drops below 10 ppm, a circuit will be made to send a 115V AC signal to the _____ valve to _____ it.
2. Should air flow drop below 10 ppm, there is danger of a low flow of air flow to the _____ and _____.

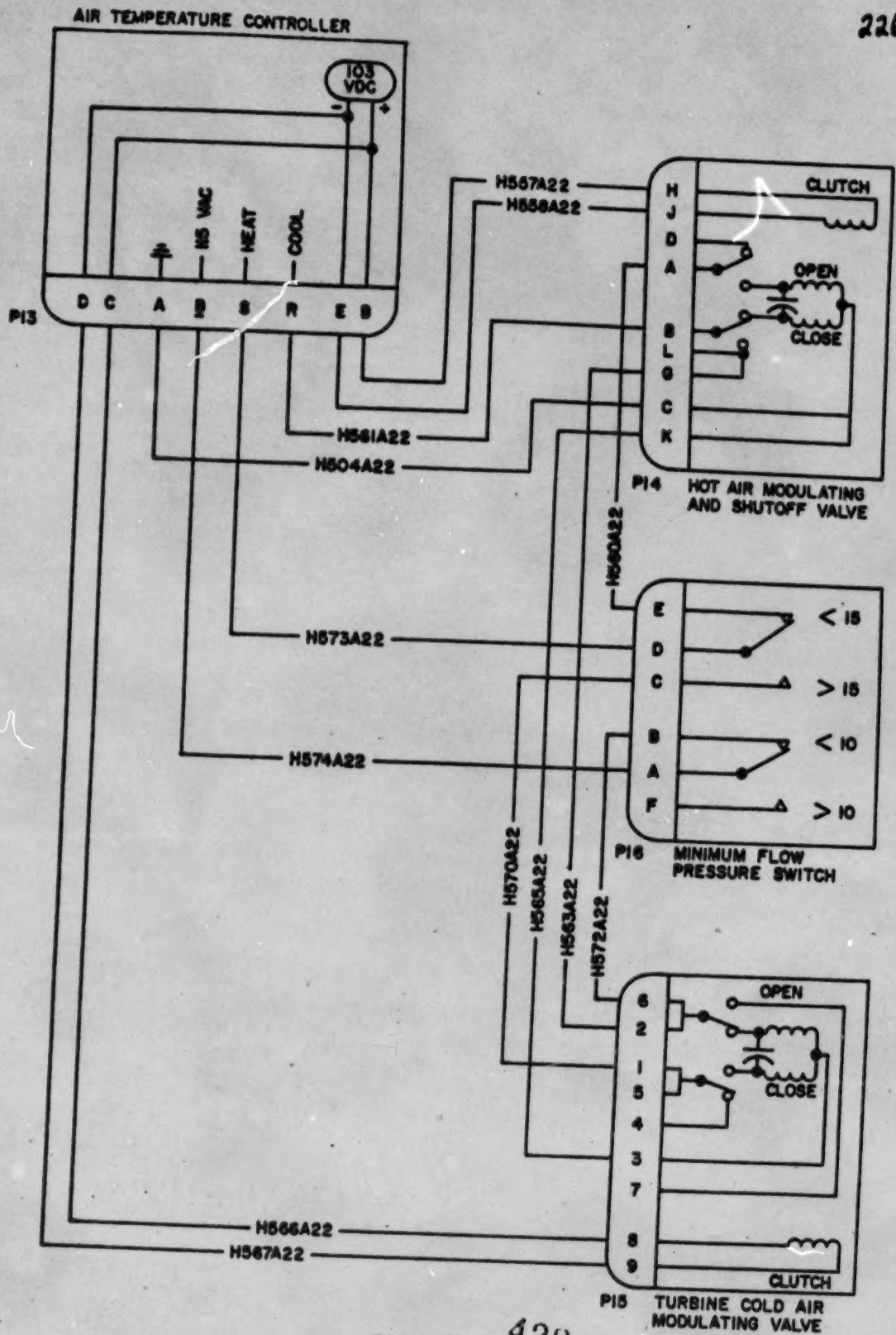


Figure 25.
49

429

2267

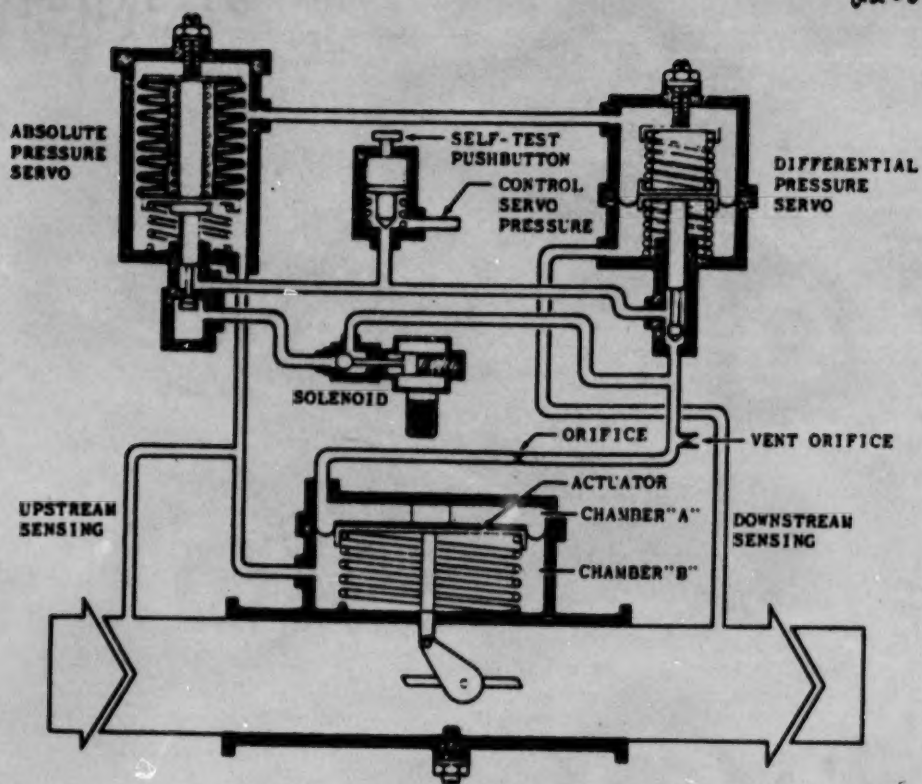
CORRECT RESPONSES TO FRAME 26: 1. cold air modulating, open
2. cabin, electronics equipment

Frame 27

The minimum upstream pressure regulator (figure 26), is placed in the cold air duct that goes to the cabin (foldout 1). The purpose of this valve is to send a good flow of cold air to both the cabin and the electronics equipment. The valve is controlled by a pressure switch in the cabin that operates a solenoid when a certain altitude is reached. Movement of the solenoid will cause the regulator to be opened or closed. This allows most of the cold air to go to the electronics equipment while some is saved for cabin pressurization.

Answer the statements True as (T) or False (F).

- _____ 1. The minimum upstream pressure regulator is placed in the system to keep an adequate flow of cold air only to the cabin.
- _____ 2. A pressure switch will control the valve to make sure air flows to the electronics equipment and to the cabin.



Minimum Upstream Pressure Regulating Valve,

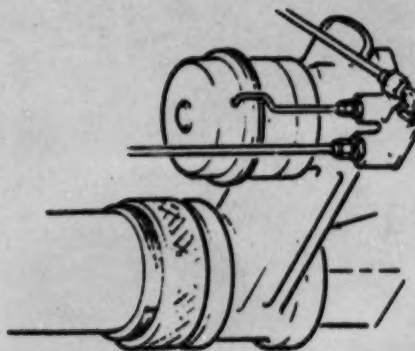
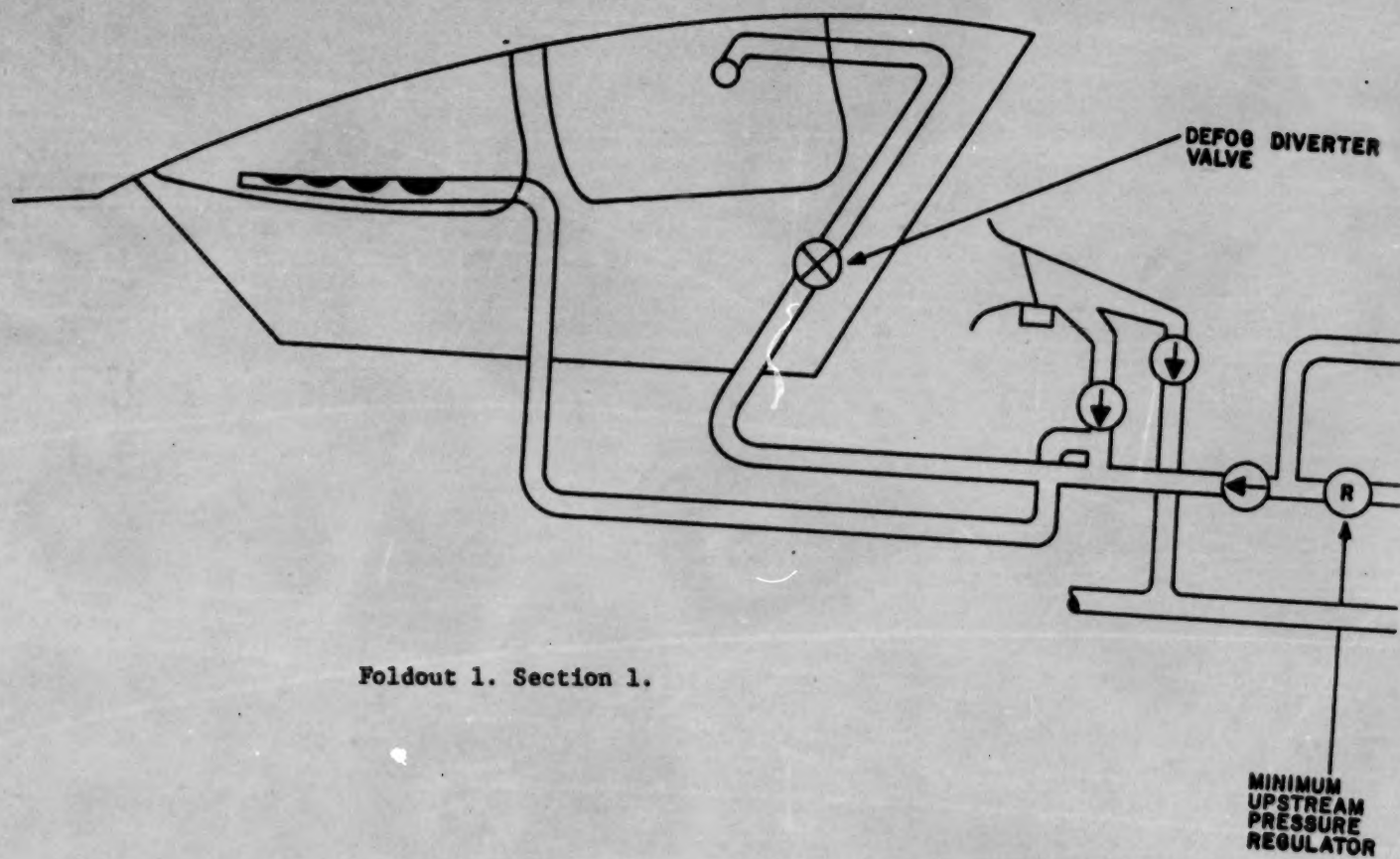
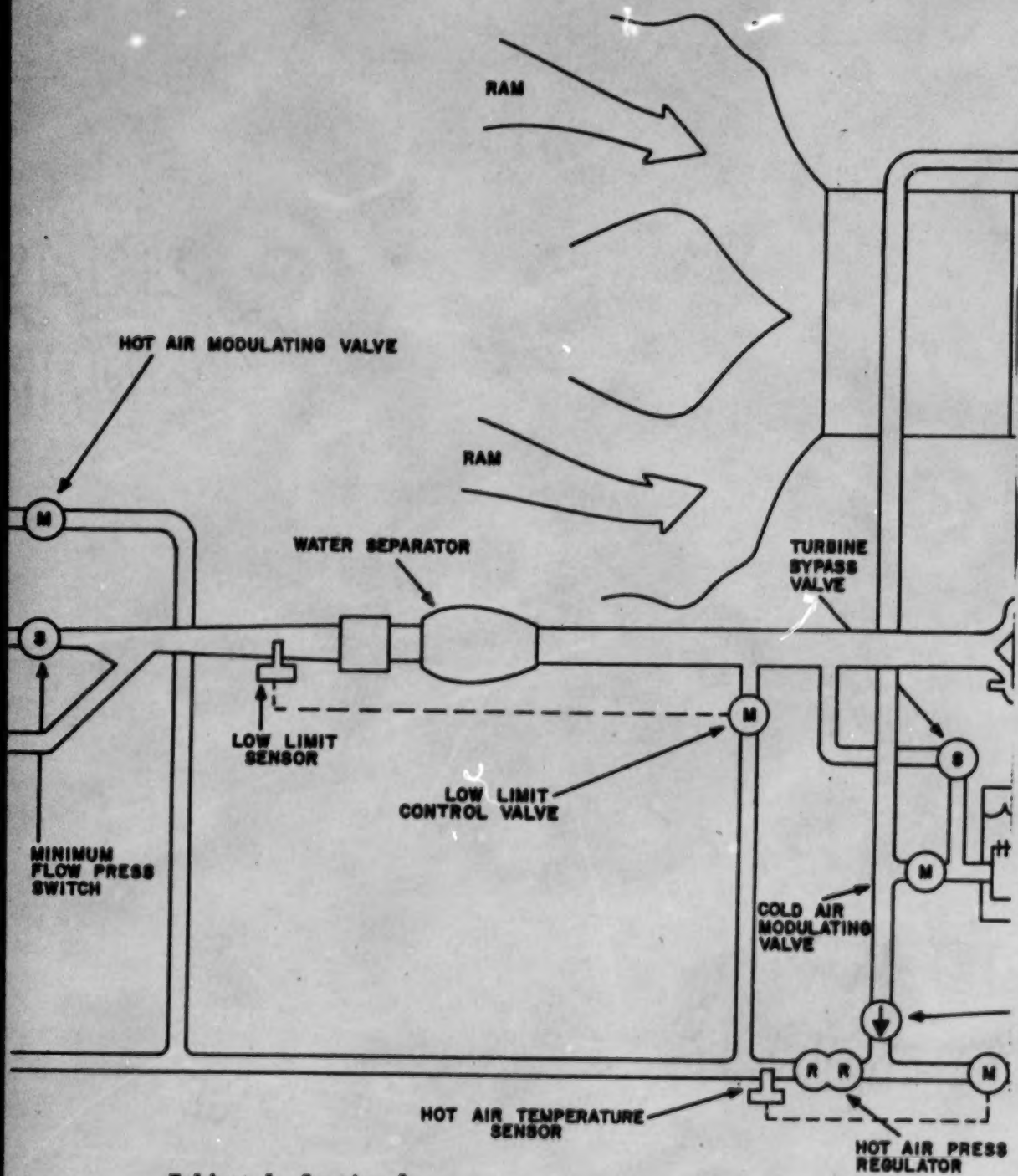


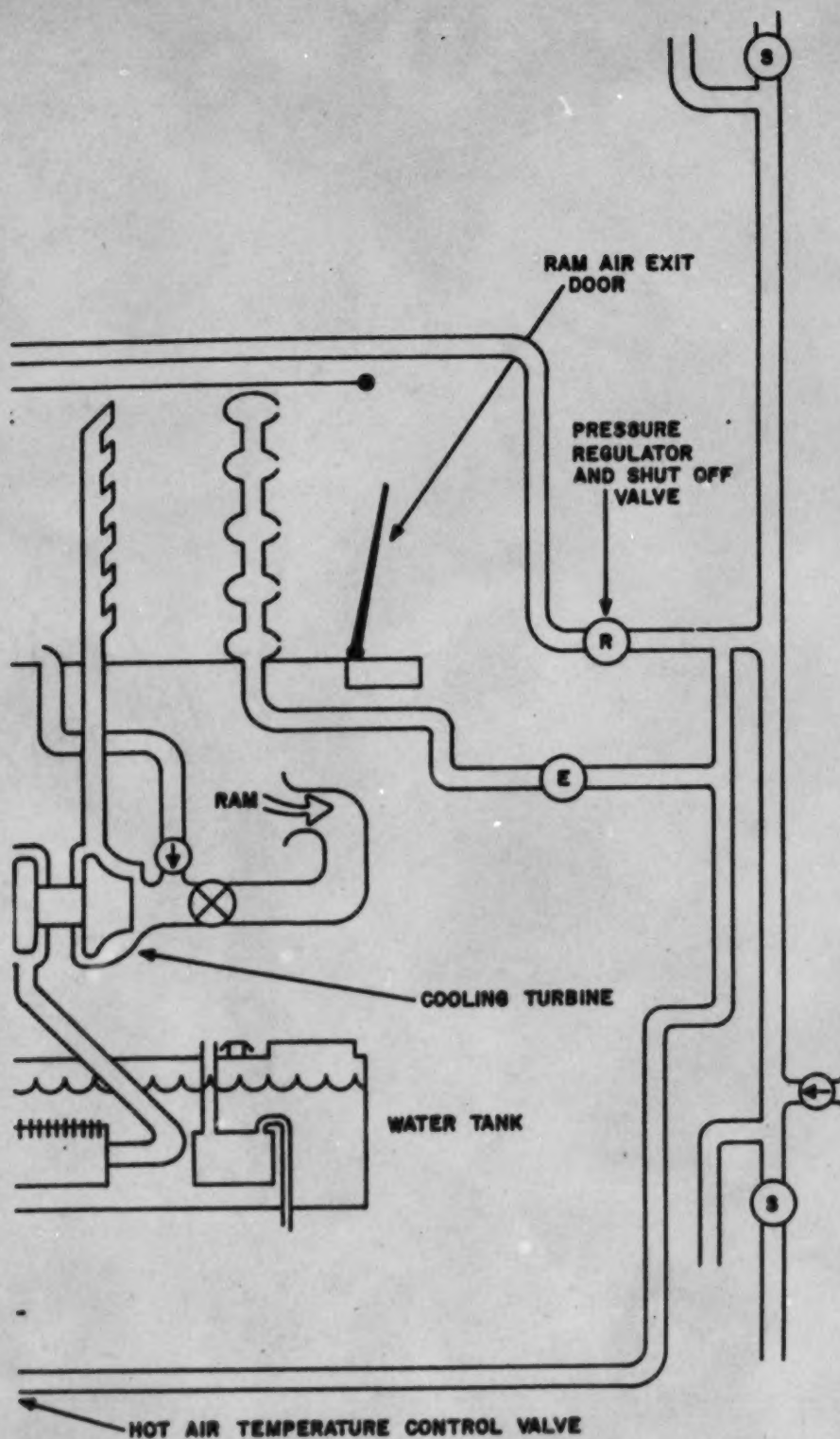
Figure 26.



433



Foldout 1. Section 2.



Foldout 1.
Section 3.

Technical Training

Aircraft Environmental System Mechanic

FIGHTER BOMBER TEMPERATURE CONTROL SYSTEM

30 March 1976



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3370th Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.
DO NOT USE ON THE JOB.

FOREWORD

This programmed text was designed for use in the 3ABR42231 Course. The text has been validated using 30 students from the subject course. Ninety percent of the students taking this text surpassed the criteria called for in the approved lesson objectives. The average student required 3 hours to complete this lesson.

OBJECTIVES

After completion of this text you will be able to:

1. Select statements that identify:
 - a. Purpose of each component.
 - b. Component operation within the system.
 - c. Purpose of the self-test system.
2. Trace electrical circuits for system operation.
3. Identify circuits affected when air flow is less than 10 ppm.
4. Identify circuits affected when the cabin overtemperature switch opens.

At the completion of this text, you will be required to obtain a score of 70% on a written test.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each frame you are asked to complete a statement or determine the answer to a question. Read the material presented and make your response as directed. After you have made your response, compare your answer with the correct answer given on the even numbered page following each frame. Write the correct answer next to your original response and then proceed to the next frame. If necessary, you may go back to check information previously given, but do not skip ahead.

Supersedes 3ABR42231-PT-309A, 25 June 1973.

OPR: TAS

DISTRIBUTION: X

TASTC - 150; TTVGC - 1

The temperature control system has the parts that control temperature of the air conditioning system. The temperature is controlled by the mixing of cool and hot air. The cold air modulating valve controls the air that is cooled. The hot air modulating valve controls the hot air that is mixed with cooled air. The minimum flow pressure switch determines the valve that will operate under various air flow and conditions. Control of the hot and cold air modulating valves is done by a temperature control box, temperature control panel, cabin sensor, overtemperature thermostatic switch and rate-of-change temperature sensor. Air temperature can be controlled from the temperature control panel either automatically or manually.

Complete the following statements by filling in the missing information in the spaces provided.

1. Air temperature can be controlled from the _____
_____.
2. Temperature control is accomplished by a temperature control box, temperature control panel, _____
_____, overtemperature thermostatic switch and
a _____ temperature sensor.
3. The temperature control system will control the position of the
_____ and _____ air modulating valves.

2275

- CORRECT RESPONSES TO FRAME 1:
1. temperature control panel
 2. cabin sensor rate-of-change
 3. hot, cold

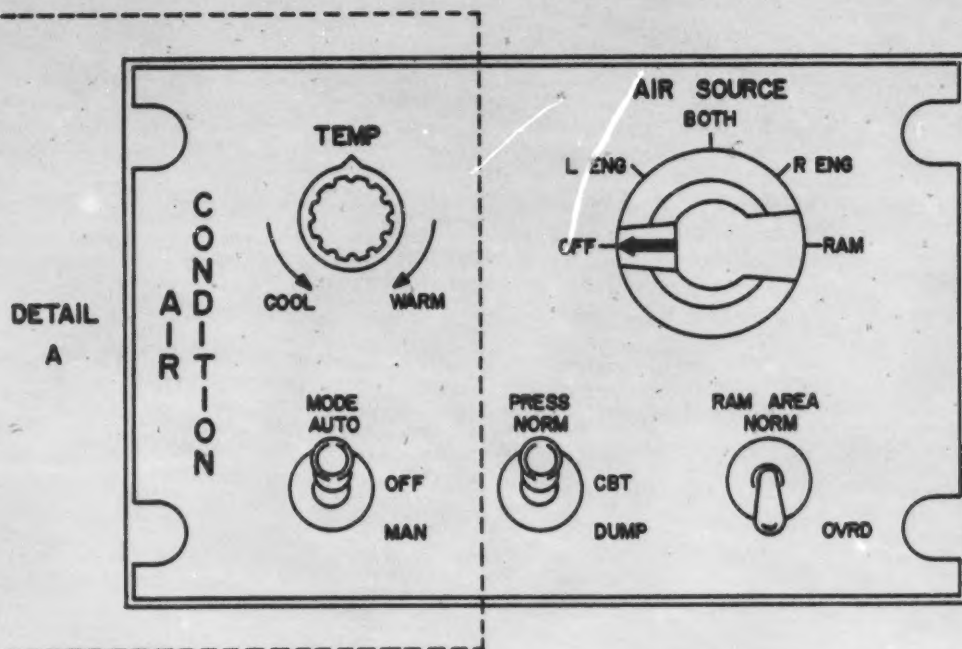
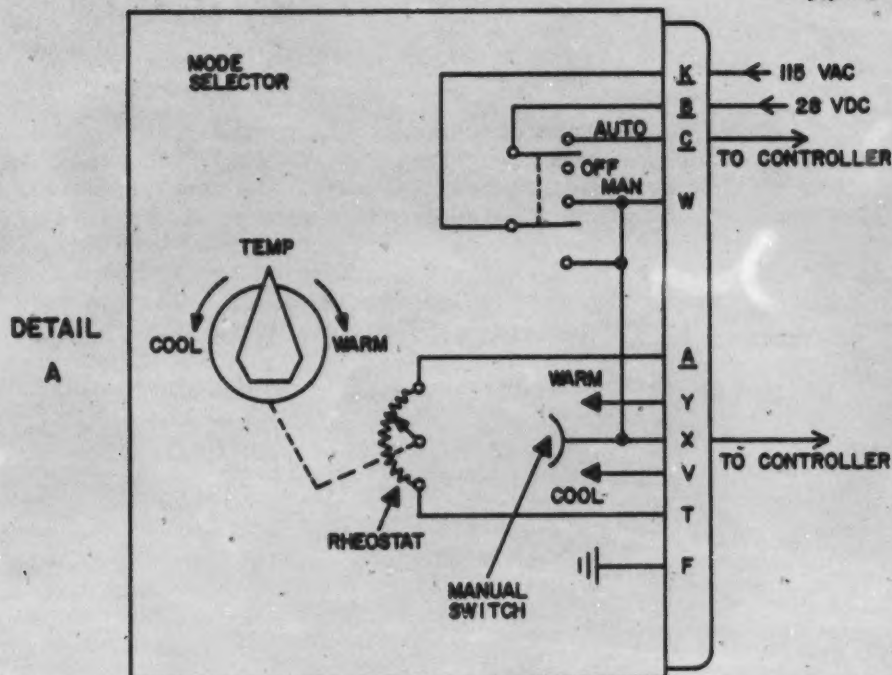
Frame 2

The switches used to control the air source, air conditioning and pressurization parts are on the air conditioning control panel. The panel has the air source control switch, ram area switch, pressurization switch, mode switch and the temperature selector. For temperature control we will discuss the mode switch and temperature selector. Figure 1 shows the electrical circuitry and the control panel face. When the mode switch is moved to automatic it will supply 28V DC and 115V AC to the temperature control box. In this position, temperature control is obtained by moving the (temperature selector) to the desired temperature. With the mode switch to manual, the selector must be moved to the far left or right to control temperature. In the far left (cool) position the selector makes a circuit between X and V. This is the cool side of the switch. In the far right (warm) position a circuit is made from pin X to pin Y. This is the warm side of the switch. The selector must be HELD in the extreme positions to have manual operation.

Complete the following statements by filling in the missing information in the spaces provided.

1. Manual temperature control is accomplished by moving the temperature switch to the _____ positions.
2. The temperature rheostat is part of the _____.

2276



AIR CONDITIONING CONTROL PANEL

Figure 1.

2277

- CORRECT RESPONSES TO FRAME 2: 1. extreme
2. temperature selector

Frame 3

The cabin temperature sensor is in the cabin. It will sense air temperature through electrical resistance. This sensor has a negative coefficient of resistance. The sensor is used to control cabin temperature in the automatic mode of operation. This is done by a signal sent to the temperature control box by the sensor. The box will send a hot or cool signal to show the resistance change of the sensor. A fan is used to keep flow of air across the sensor. The fan runs on 115V AC when the mode switch is moved to auto or manual.

Mark the following statements true (T) or false (F) in the spaces provided.

1. _____ The cabin temperature sensor is positive coefficient.
2. _____ As cabin temperature increases around the cabin sensor, sensor resistance decreases.
3. _____ A fan is used to assure air flow across the cabin sensor.



3.

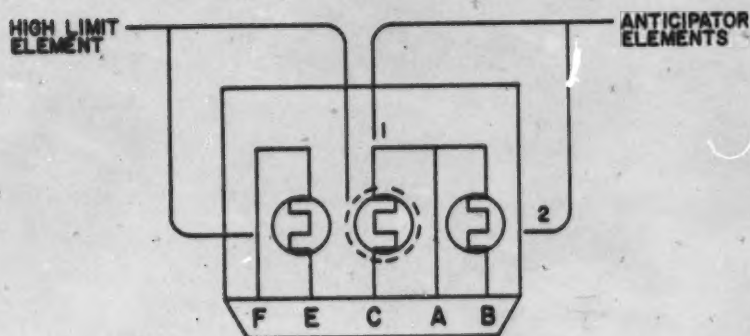
Cabin Temperature Sensor



Fan

441

The rate-of-change temperature sensor is in the conditioned air duct. It is put in the duct at a point just before where the air reaches the cabin. It is a three element sensor (negative coefficient). Two of the elements are duct anticipator elements. One of the two elements is lagged by the use of insulation. The other is directly exposed to air flow. The purpose of the uninsulated element is to cancel the signal from the cabin bridge. This will keep the temperature from going too hot or cold before the cabin sensor can sense the change and stop the signal. The purpose of the insulated or lagged element is to stop the signal sent by the other anticipator element. This will allow the cabin bridge to take control of the system. The third element (called the high limit) is a safety device which will cause the system to run full cold if the duct temperature goes above 200°F.



Mark the following statements true (T) or false (F) in the spaces provided.

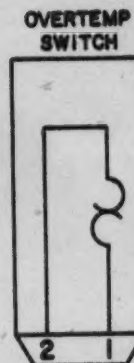
1. ☐ The rate-of-change temperature sensor is located in the cabin compartment.
2. ☐ The rate-of-change temperature sensor is a three element person.

2279

CORRECT RESPONSES TO FRAME 3: 1. F 2. F 3. T
 CORRECT RESPONSES TO FRAME 4: 1. F 2. T

Frame 5

The cabin overtemperature switch is a normally closed thermostatic switch. It is put in the end of the cabin air inlet duct. The switch will control the maximum duct temperature in auto and manual should the high limit part of the automatic temperature control system fail. The switch will open at a duct temperature of 250°F. When the switch is open, 115V AC from the air temperature control box causes the hot air modulating valve to close. The cold air modulating valve will open and cause the system to run full cold. As soon as the duct temperature falls to 250°F the switch will close. Normal operation of the temperature control system resumes.



Complete the following statements by filling in the missing information in the spaces provided.

1. The cabin overtemperature switch is a normally _____ switch.
2. Opening the overtemperature switch occurs at a duct temperature of _____ degrees F.

Frame 6

Complete the following statements by filling in the missing information in the spaces provided.

1. The _____ temperature sensor is a three element resistance type resistor.
2. The rate-of-change temperature sensor consists of two _____ elements and a _____ element.

3. The high limit element limits maximum duct temperature to _____ degrees F.
4. The high limit element will oppose _____ temperature selections.
5. The cabin temperature sensor fan will operate when the mode switch is placed in the _____ or _____ positions.
6. The cabin temperature sensor has a _____ coefficient of resistance.
7. When the cabin overtemperature switch opens the hot air modulating valve will _____ and the cold air modulating valve will _____.
8. The cabin overtemperature switch is normally _____.

Frame 7

The control box for the air temperature controller is shown in foldout #1. As we talk about each part of the box look at foldout #1 to find out where the part is located. This box is made up of a cabin bridge(1), an anticipator bridge(2), a high limit bridge(3), a DC power supply(4), and an overheat relay(5). The bridges will be covered in later frames. First we will talk about the power supply for the box. The box gets 115V AC through pin G(6) from a circuit breaker outside the box (not shown). This power is sent to the cool and heat transistors(7, 8) and the 103V DC power supply(4). The 103V DC power supply will change 115V AC to 103V DC, which is sent to run the modulating valve clutches. The box also has a self test system (not shown) used to check the modulating valve clutches and temperature sensors. The system will be covered in your next lab.

Mark the following statements true (T) or false (F) in the spaces provided.

1. _____ The AC power supply delivers power to the transistors and to the 103V DC power supply.
2. _____ The DC power supply changes 115V AC to 28V DC.

Next we will talk about the manual/auto relay(9) on foldout #1. It is made up of two sets of contacts and a relay coil. The relay's job is to set the system in manual or automatic control. When the system is put in automatic, the relay will energize and pull the contacts down. Now the transistors will send power to run the hot and cold air modulating valves (not shown). When the system is in manual the relay is de-energized and the contacts are up. Now the hot and cold air modulating valves will receive their power from the manual part of the temperature rheostat (not shown).

Mark the following statements true (T) or false (F) in the spaces provided.

1. _____ When the manual/auto relay is energized the system is in manual.
2. _____ When the system is in automatic the modulating valves get their power from the transistors.

CORRECT RESPONSES TO FRAME 5: 1. closed 2. 250°F

CORRECT RESPONSES TO FRAME 6: 1. rate-of-change
2. anticipator, high limit
3. 200°F
4. hot
5. automatic, manual
6. negative
7. close, open
8. closed

CORRECT RESPONSES TO FRAME 7: 1. T 2. F

We will now discuss the overheat relay(5) on foldout #1, use foldout #1 as we go through this frame to see how the relay works. The overheat relay is made up of a relay coil and two sets of contacts. The relay is energized at all times when the plane has power. When the relay is energized it will pull the contacts down and let the manual/auto relay(9) control the modulating valves (not shown). The relay is controlled by an overheat switch (not shown) which is located outside the box. The switch was covered in frame 5, so we will not go over its operation. When the switch is open the relay is de-energized and the contacts go up, now power is sent over the upper contacts to close the hot air modulating valve. The lower contact has no power so the cold air modulating valve will go to the spring loaded open position. This will keep duct temperature down to 250 degrees F. When the temperature drops back below 250 degrees F. the switch will close and the relay will energize, thus letting the manual/auto relay control temperature.

Mark the following statements true (T) or false (F) in the spaces provided.

1. _____ The overheat relay is energized during an overheat condition.
2. _____ During an overheat condition the cold air modulating valve is closed.

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CORRECT RESPONSES TO FRAME 8: 1. F 2. T
 CORRECT RESPONSES TO FRAME 9: 1. F 2. T

Frame 10

Look at figure 2 as we discuss parts of the air conditioning panel and air temperature controller circuits. The first part we will talk about is the cabin bridge. Notice that the temperature selector and the cabin sensor make up two legs of this bridge. The other two legs contain fixed resistors. Let's see how these circuits work when the mode selector is in AUTO. This means that the MAN/AUTO relay has pulled the cool and heat contact points DOWN. Trace the circuit on figure 2 as we go through the current flow. Remember, current flows from negative to positive. Start at the ground point on the cabin bridge and follow the flow down through pin R and to the cabin sensor. This sensor has a negative coefficient. What that means is, if the temperature around the sensor is high, its resistance will drop. This will let the current go through the sensor, back through pin N to the bridge, and out point A to the hot and cold transistors. The windings of the transistors are arranged so that the first one to get current goes OFF and the next one goes ON. In this case the heat transistor got the current first so it went off. The cool transistor got current next so it went on. This allows current from the 115V AC power supply to flow across the cool contact points to the hot and cold air modulating valves (not shown).

Complete the following statements by filling in the missing information in the spaces provided.

1. The cabin bridge consists of the cabin _____, temperature _____, and two _____ resistors.
2. When the power goes through the first winding, it is turned _____, therefore, the power for the second windings will be turned _____.

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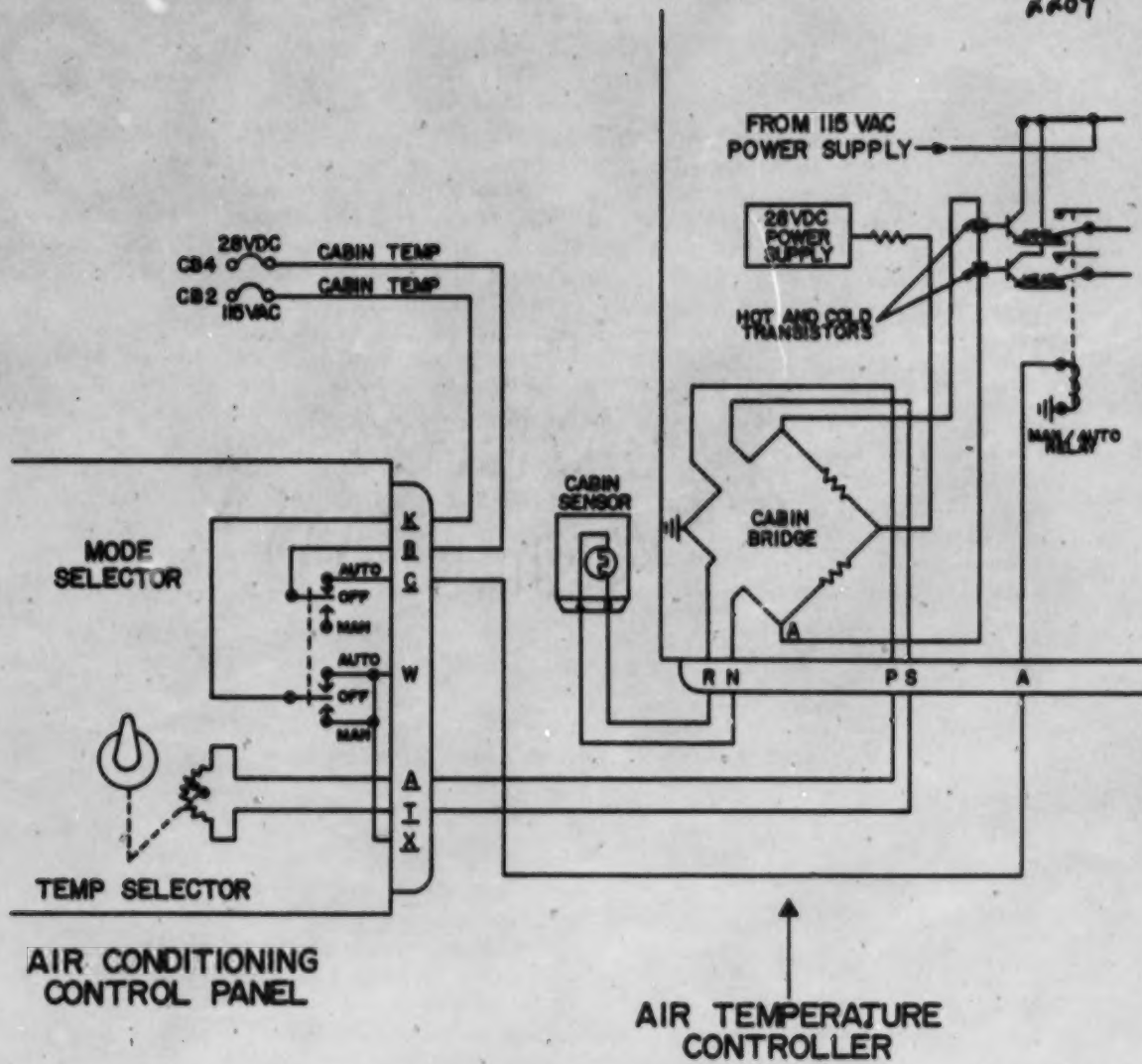


Figure 2.

CORRECT RESPONSES TO FRAME 10:

1. sensor, selector, fixed
2. off, on

Frame 11

As we discuss the next two paragraphs look at figure 3. The anticipator bridge works with the cabin bridge to keep from overshooting the temperature setting. Previously we learned that the uninsulated (or fast element) and insulated (or slow element) are used to stop overshooting. You will now see how these elements do this. Let us say the cabin is receiving hot air and the cabin bridge sends out a signal for cold air. Since the anticipator element is in the duct that leads to the cabin, it will be the first part to sense the change in temperature. We do not want the cabin to get too cold, so as soon as the fast element senses this change, its resistance will increase. Since current takes the path of least resistance, it will flow in the opposite direction. Current then flows through the fixed resistor of the next leg, then through the cold winding turning it off. Current then flows through the hot winding and cancels the signal sent by the cabin bridge. As soon as the resistance of the slow element equalizes with the resistance of the fast element, the bridge will balance and stop the signal.

Mark the following statements true (T) or false (F) in the spaces provided.

1. _____ The anticipator bridge works in conjunction with the cabin bridge to prevent overshooting.
2. _____ Current will always take the path of least resistance.

Frame 12

The high limit bridge is a safety feature, figure 3. When the duct temperature is more than 200°F, the resistance of the high limit sensor will start to decrease. When this happens the current will flow through the sensor and out the bottom of the bridge at point C. It will then flow through the hot winding and turn it OFF. This current then flows through the cold winding and turns it ON. This then sends a cold signal to the hot air modulating valve and cold air modulating valve. The diode in the high limit bridge is used to stop a signal, should there be a temperature drop in the duct. The high limit bridge is stronger than the other two bridges combined. This will allow the signal from the high limit bridge to override signals sent by the other two bridges. The cabin bridge is the weaker of the three bridges.

Mark the following statements true (T) or false (F) in the spaces provided.

1. _____ The high limit bridge is a safety feature.
2. _____ The high limit bridge will send a hot signal to the valves when duct temperature exceeds 200°F.

CORRECT RESPONSES TO FRAME 11:

1. $\frac{T}{T}$ 2. $\frac{T}{F}$

CORRECT RESPONSES TO FRAME 12:

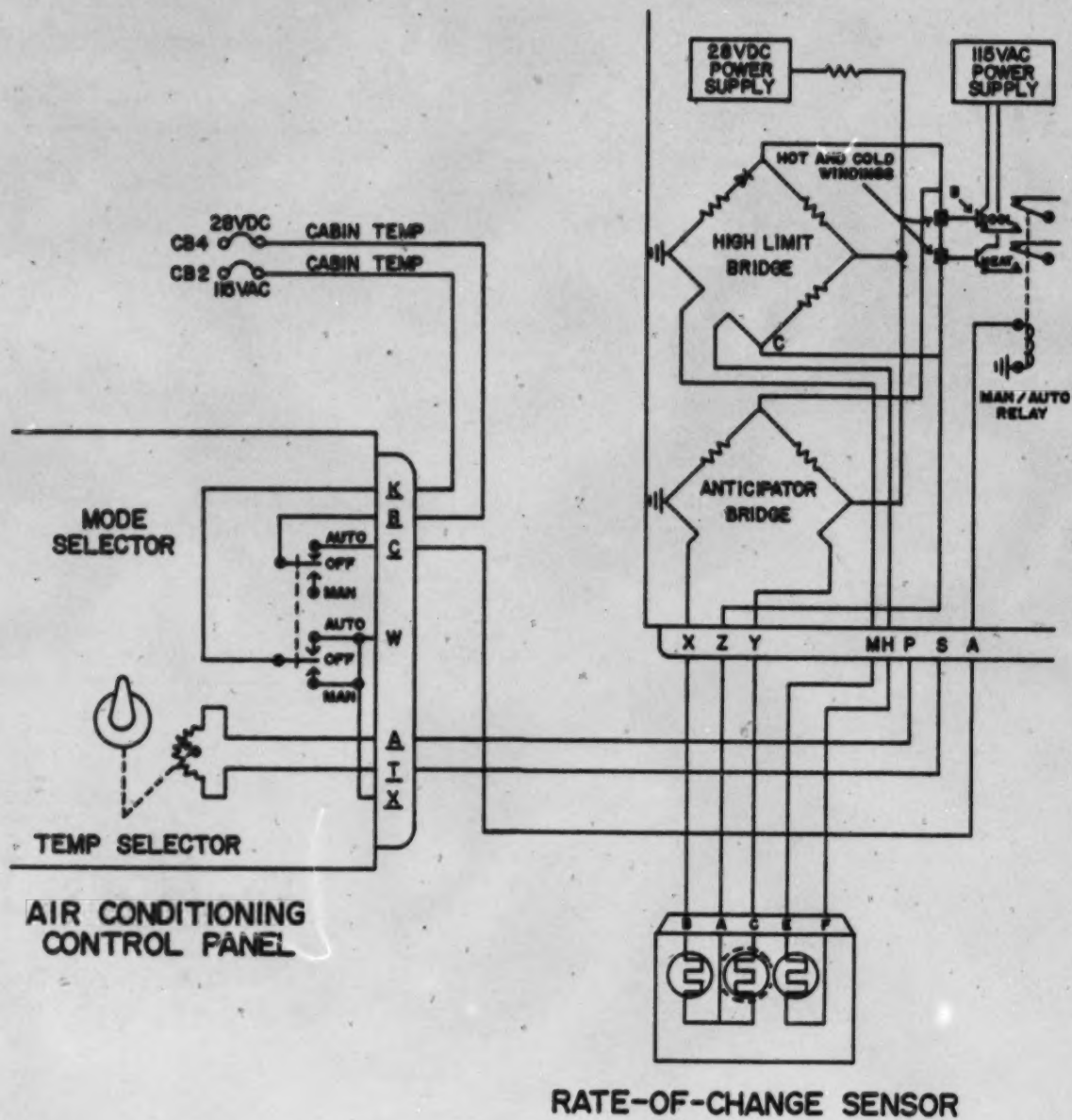
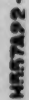
1. $\frac{T}{T}$ 2. $\frac{T}{F}$ 

Figure 3.

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Technical Training

Aircraft Environmental Systems Mechanic

FIGHTER/BOMBER TEMPERATURE CONTROL WIRING DIAGRAM

23 January 1976



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

2289

Environmental Pseudraulic Branch
Chanute AFB, Illinois

3ABR42231-WB-309A

FIGHTER/BOMBER TEMPERATURE CONTROL WIRING DIAGRAM

OBJECTIVES

Given a temperature control wiring diagram and a workbook, determine operation by tracing circuits and analyzing selected malfunctions. From a list of statements and responses, select 70% of the responses correctly.

EQUIPMENT

Box of Colored Pencils

Basis of Issue
1/student

PROCEDURE

Open foldout 1. This is the wiring diagram for the complete air conditioning temperature control system. In the previous PT we discussed all the circuits of the air conditioning temperature control system. Do this workbook step-by-step and do not skip any steps. The diagram will be checked. Using colored pencils, trace the circuits with the color called for in each step.

Step 1

The power circuits are energized when electrical power is ON and the mode switch is OFF. Use a red pencil to trace the power circuits. Start at the 28V DC circuit breaker CB4, trace current flow from the circuit breaker through wire H503A22 point A. From point A trace current to pin B of the temperature control panel. From pin B to the upper contact of the mode selector switch. With the mode switch OFF current flow stops at this point. At point A trace current flow through wire H503B22 to the overtemperature switch. Since the overtemperature switch is normally CLOSED current will flow through the switch, out wire H530A22 to pin K of the control box. Inside the control box current from pin K energizes the cabin overheat relays. Now trace current flow from circuit breaker CB2 over wire H501A22 through pin K to the lower contact of the mode selector switch. When the mode switch is in the OFF position, current will not pass through the switch contacts.

Step 2

Use a green pencil and trace the following circuits. Draw the mode selector switch contacts to the manual (down) position. 115V AC moves current through the switch to pin W of the air conditioning control panel.

OPR: TAS

DISTRIBUTION: X

TAS - 500; TTVGC - 1

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Current moves on wire H540B22 to the cabin temperature fan. The fan will operate at this time. In the air conditioning panel, trace current flow from the mode selector switch to point B. Now trace current flow out pin X and over wire H532B22 to pin G of the air temperature control box. In the control box current moves through pin G to the AC and DC power supplies. The 103V DC power supply sends current to the HOT and COLD air modulating valve. The power is used to engage the solenoid clutches. The clutches connect the valve actuators to the butterfly valves for operation. Trace current flow from the negative side of the 103V DC to point C. From point C out pins D and E to the valve clutches. Trace current through both valve clutches, back through pins C and B to the positive side of the 103V DC power supply.

Step 3

Start tracing at point B with a blue pencil. Trace current flow to the manual switch of the temperature selector. Draw the manual switch to the cool position. 115V AC sends current through the switch to pin V of the temperature control panel. From pin V current moves through wire H533B22 to pin B and to the upper set of contacts of the manual/auto relay. STOP tracing at this point. Under normal operating conditions current would go through the upper contacts of the overheat relay. From the overheat relay current flow moves the cold and hot air modulating valve to the cold position.

Note: Since AUTOMATIC and MANUAL use the same wires from the manual/automatic relay to the hot and cold air modulating valves, these circuits will be traced later.

Step 4

With a brown pencil draw the temperature selector manual switch to the manual warm position. Now trace the following circuits. Current flows out pin Y through wire H531B22 to pin C of the temperature control box. From pin C (remember C = c) current moves in the control box and to the lower contacts of the manual/auto relay. STOP tracing at this point. The remaining circuits will be traced when the automatic system is covered.

Step 5

With a purple pencil draw the mode switch contacts to the automatic (up) position. Note, that the circuits you have drawn in green will stay energized. 28V DC from circuit breaker CB4 can now cause current to flow across the upper switch contact and out pin C. Trace the current flow over wire H525B22 to pin A of the temperature control box. From pin A current flow will move through the coil of the manual/auto relay and pull the relay contacts down. With the relay contacts down, a circuit is completed from the temperature control box transistors to the hot and cold modulating valves. Draw the circuits from the transistors to the manual/auto relay. STOP at this point.

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Note: The mode switch controls the position of the manual/auto relay. With the mode switch in manual the relay is deenergized. Temperature control is accomplished by holding the temperature selector to manual warm or cool. Placing the mode switch to automatic energizes the manual/auto relay. When the manual/auto relay is energized, power to move the modulating valves to hot or cold is from the hot windings. Control of the windings is done by the temperature control rheostat, temperature sensors, and the bridge circuits.

Step 6

The following 5 steps will trace the common circuits. The circuits are common for both automatic and manual temperature controls will use these circuits to run the hot and cold modulating valves. Use a yellow pencil to trace the cooling circuit. Start at the upper set of contacts of the manual/auto relay. Trace current flow to the contacts of the cabin overheat relay. From the cabin overheat relay trace current flow to pin R of the temperature control box. Current flows from pin R over wire H561A22 to pin B of the hot air modulating valve. The valve closed limit switch will send current through the closed windings of the valve actuator. The hot air modulating valve ground is at pin C. Trace current through the closed winding, out pin C. From pin C over wire H564A22 to pin A of the temperature control box. As soon as the hot air modulating valve closes, the closed limit switch will open and send current out pin G over wire H563A22 to pin 2 of the cold air modulating valve. The valve limit switch will send current through the actuator opening windings. The cold air modulating valve ground is at pin 3 through wire H565A22 to pin K of the hot air modulating valve. Trace through pin K and out pin C, since both valves use a common ground.

Step 7

Use an orange pencil to trace the heating circuit. Start at the lower contacts of the manual/auto relay. Trace current across the contacts of the cabin overheat relay. From the overheat relay trace current down to pin S of the temperature control box. Current moves through wire H573A22 from pin S to pin D of the minimum flow pressure switch. At this time air flow through the pressure switch will be above 15 ppm. Because of this, current will move through the switch from pin D to pin C. Current then moves from pin C through wire H570A22 to pin 1 of the cold air modulating valve. The cold air modulating valve will start to close.

Step 8

Keep in mind, that when the air conditioning system does close the cold air modulating valve, the flow of air through the minimum flow pressure switch is reduced. Use an orange pencil to trace the remainder of the warm circuit. Start at pin D of the minimum flow pressure switch. At this time air flow through the minimum flow pressure switch has dropped to less than 15 ppm, due to the cold air modulating valve moving toward closed. Current now moves through the minimum flow pressure switch from pin D to pin E. From pin E current flows over wire H56QA22 to pin A of the hot air modulating valve. The hot air modulating valve will open.

Note: To be sure that there is a good flow of cold air to the cabin and electronics equipment, the minimum flow pressure switch will open the cold air modulating valve, if air flow falls below 10 ppm.

Step 9

With a light blue pencil trace the following circuit. Start to trace at pin B of the temperature control box plug P13. Pin B receives 115V AC from the control box internal circuits. Trace current from pin B to wire H574A22 to pin A of the minimum flow pressure switch. When air flow falls below 10 ppm the minimum flow pressure switch will close a circuit between pin A and pin E. Current will flow out pin B over wire H572A22 to pin 6 of the cold air modulating valve. The cold air modulating valve will open.

Step 10

Note the circuit you have drawn in red. The circuit will pass through the overtemperature switch and energize the cabin overheat relay. Should duct temperature be more than 250°F at the overtemperature switch, the switch will open and deenergize the cabin overheat relay. Current flows from point E in the control box across to the upper contact of the upper set of contacts. This will energize the circuits you have drawn in yellow. With these circuits energized the hot and cold air modulating valves move to the cold positions.

Step 11

In the spaces provided, fill in the missing information. You may use the wiring diagram when necessary.

1. The temperature selector is connected to the _____ bridge.
2. When the mode switch is in the automatic position, the manual/auto relay will be _____ (energized/deenergized).

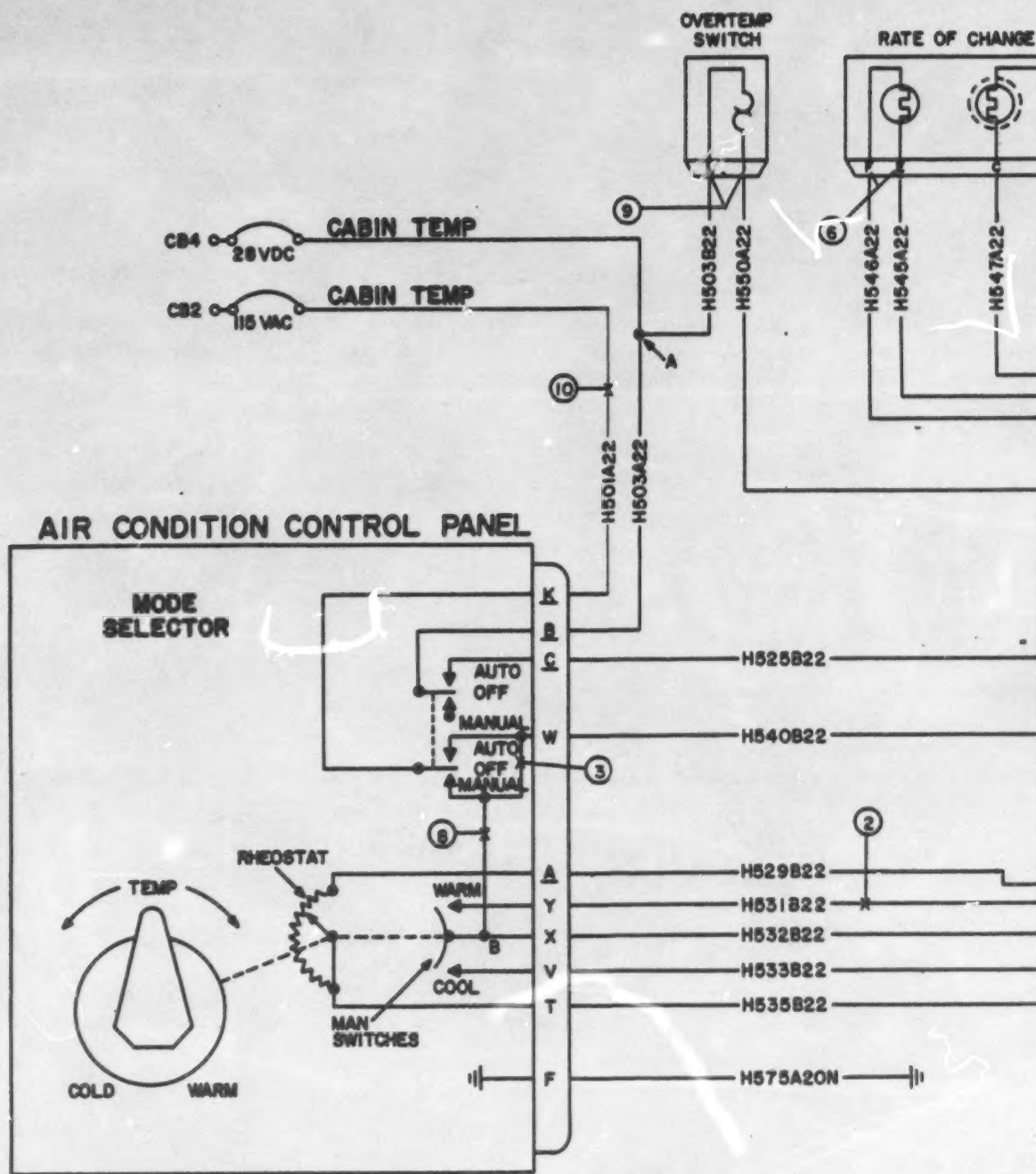
2293

3. Under normal operating conditions, the cabin overheat relay will be _____ (energized/deenergized).
4. When the mode switch is in the OFF position, the hot and cold air modulating valve clutches will be _____ (energized/deenergized).
5. When air flow through the minimum flow pressure switch falls below 10 ppm, the cold air modulating valve will _____ (open/close).
6. In the automatic mode the _____ deliver current to move the hot and cold air modulating valves hot or cold.
7. Opening the overtemperature thermostatic switch will _____ (energize/deenergize) the _____ relay.
8. The hot and cold air modulating valves receive _____ V DC and _____ V AC from the temperature control box.
9. The temperature selector consists of manual _____ and a _____.
10. The temperature control box has a _____ feature.

Step 12

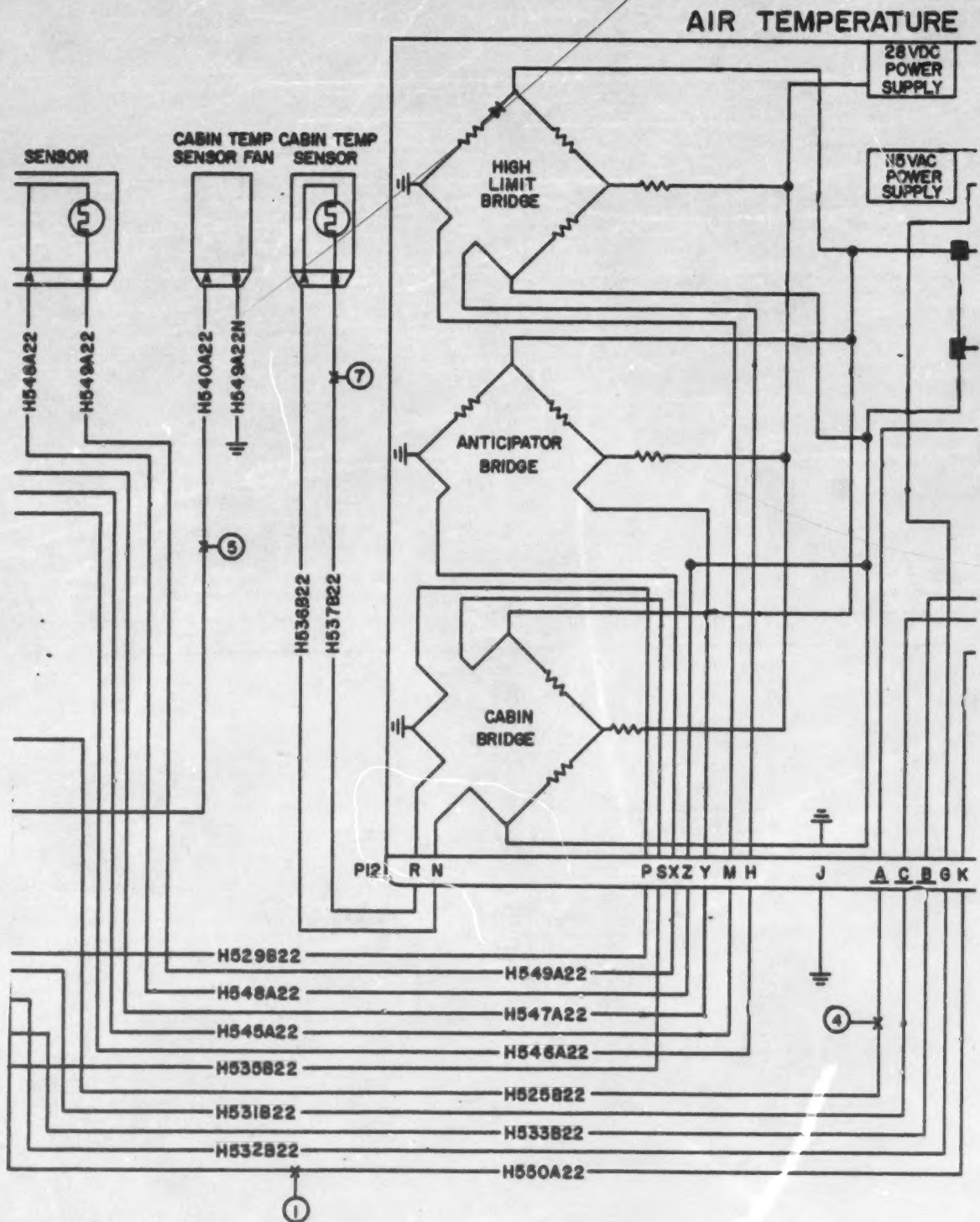
There are 10 circled numbers on foldout 1 that indicate opens or shorts. Below are 10 statements indicating troubles in the air condition temperature control system. Read the trouble statement then select the trouble number that can cause the condition given.

1. _____ Manual warm inoperative, automatic warm is okay.
2. _____ Cabin receives cold air in automatic, but works normally in manual.
3. _____ Cabin receives hot air in automatic, but works normally in manual.



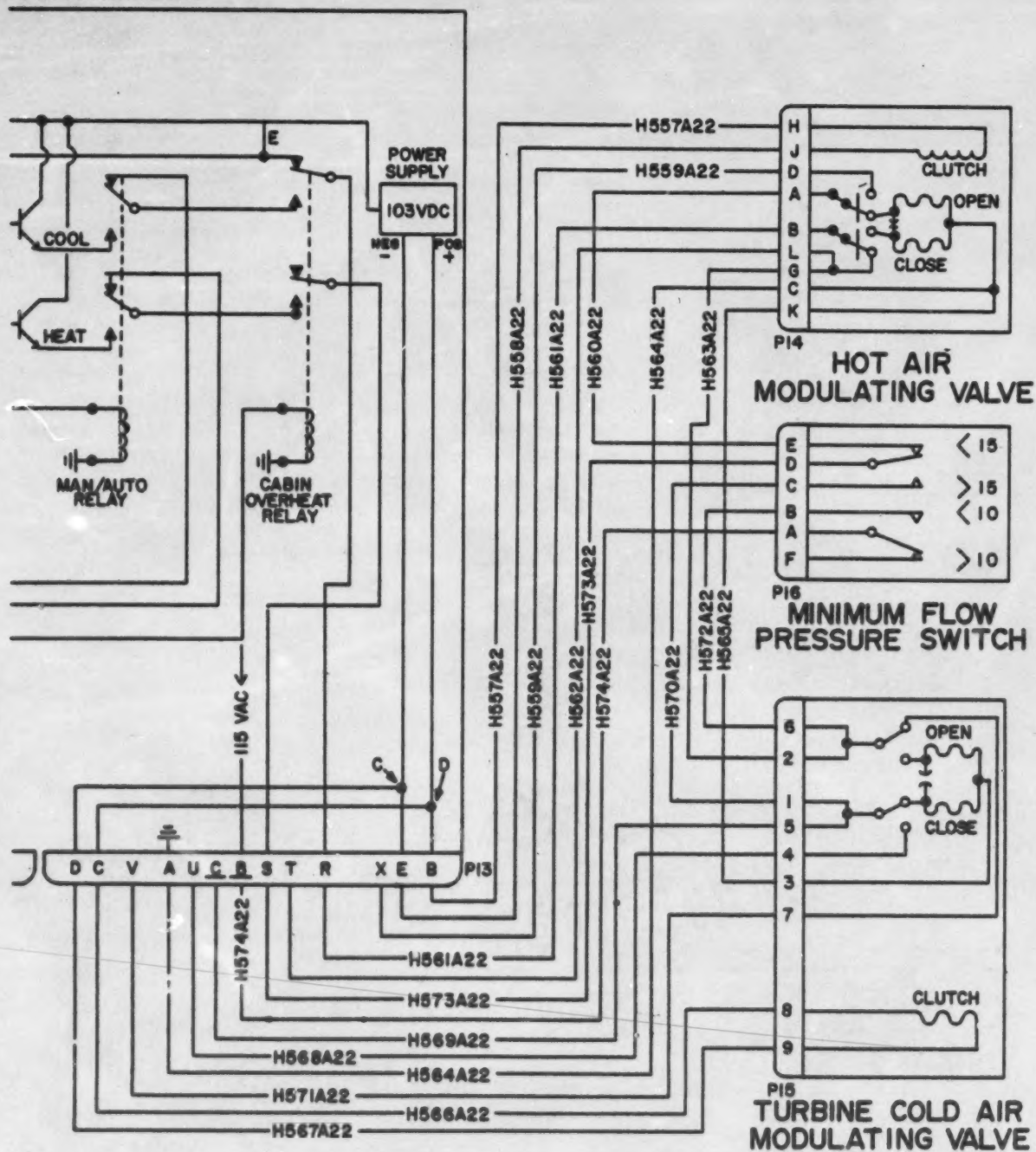
Foldout 1. Section 1.

4. _____ Air conditioning system inoperative.
5. _____ Air conditioning system is inoperative in automatic, but works normally in manual.
6. _____ Air conditioning system runs full cold in automatic and manual.
7. _____ Cabin temperature sensor fan inoperative.
8. _____ Cabin temperature sensor fan inoperative in manual only.
9. _____ Cabin temperature sensor fan works okay, manual and automatic temperature control inoperative.
10. _____ Air conditioning system will not run cold in overheat condition.



Foldout 1. Section 2.

CONTROLLER



Foldout 1, Section 3.

Technical Training**Aircraft Environmental System Mechanic****COMPONENT, IDENTIFICATION, OPERATIONAL CHECK
AND TROUBLESHOOTING**

24 July 1978



**CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois**

**DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB**

COMPONENT IDENTIFICATION, OPERATIONAL CHECK
AND TROUBLESHOOTING

OBJECTIVES

Using a wiring diagram and a multimeter, perform an operational check and troubleshoot the fighter/bomber air conditioning system trainer locating the cause of four of the five malfunctions given.

EQUIPMENT

	Basis of Issue
Trainer 4024, Advanced Fighter- Bomber Air Conditioning System	1/student
Multimeter	1/student
Wiring Diagram, Cabing Temperature Control System	1/student

Supersedes 3ABR42231-WB-309, 3 December 1975.

OPR: 3370 TCHTG

DISTRIBUTION: X

3370TCHTG/TTGU-P - 500; TTVSA - 1

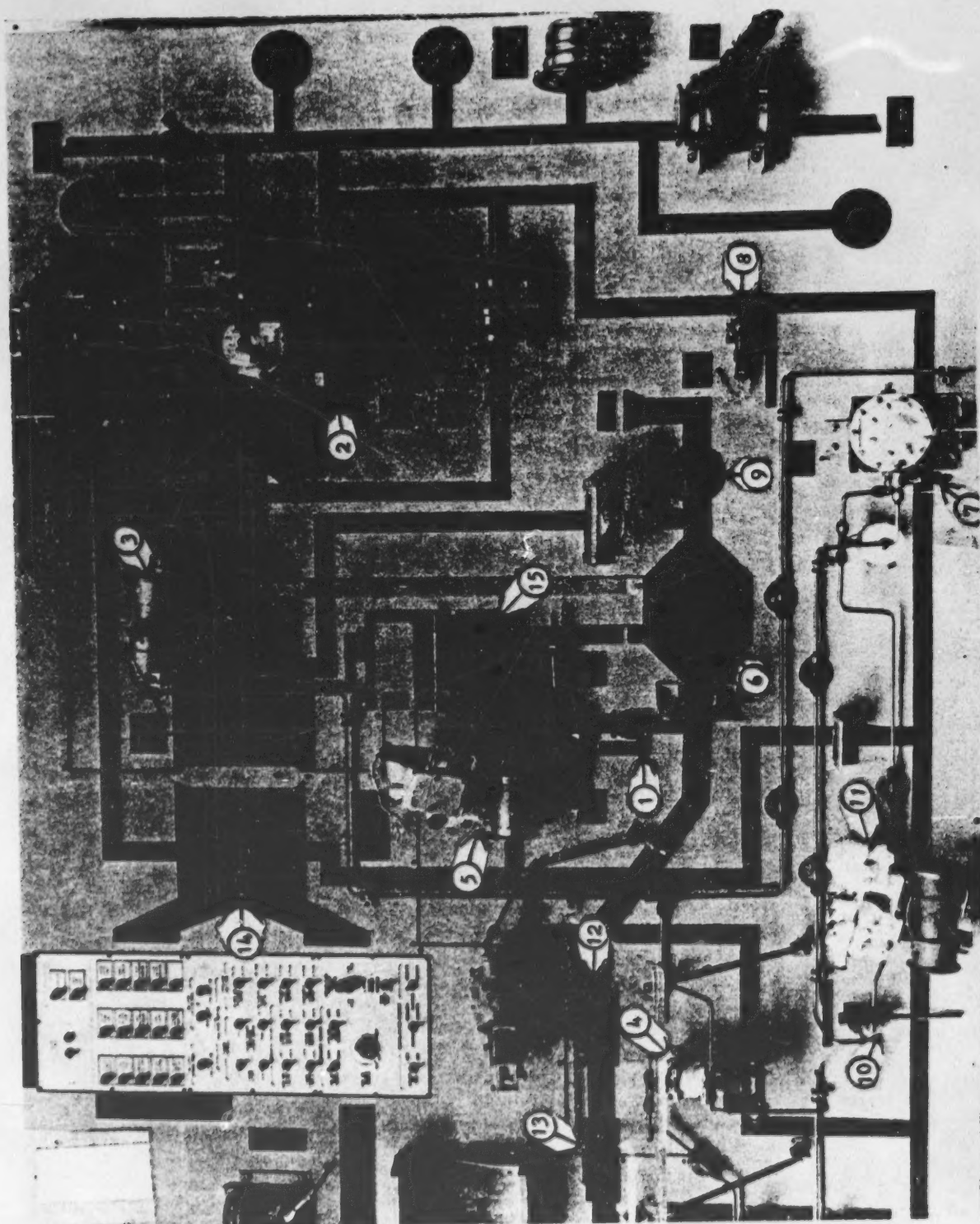


Figure 1.

2301
PROCEDURE

A. Remove all jewelry. Report to the lab instructor and inform him of the lesson you are working on. The instructor will assign you a trainer and provide the necessary materials.

B. This workbook is in three sections:

1. Location and identification of system components.
2. Air conditioning system operational check.
3. Troubleshooting.

Section 1. Location and identification of components

a. Using the trainer and figure 1, find each of the numbered parts. Write the number that goes with the name of each of these parts in the blank space to the left of the name. As you find these parts follow the flow of air from the engines through hot and cold air systems.

1. _____ Pressure regulator and shutoff valve.
2. _____ Air-to-air heat exchanger.
3. _____ Ram air exit actuator.
4. _____ Cold air modulating valve.
5. _____ Hot air pressure regulator.
6. _____ Air to water heat exchanger.
7. _____ Cooling turbine.
8. _____ Pre-whirl valve.
9. _____ Water separator.
10. _____ Turbine bypass valve.
11. _____ Low limit control valve.
12. _____ Service air-to-air heat exchanger.
13. _____ Hot air temperature sensor.
14. _____ Hot air temperature control valve.
15. _____ Bleed air low pressure switch.

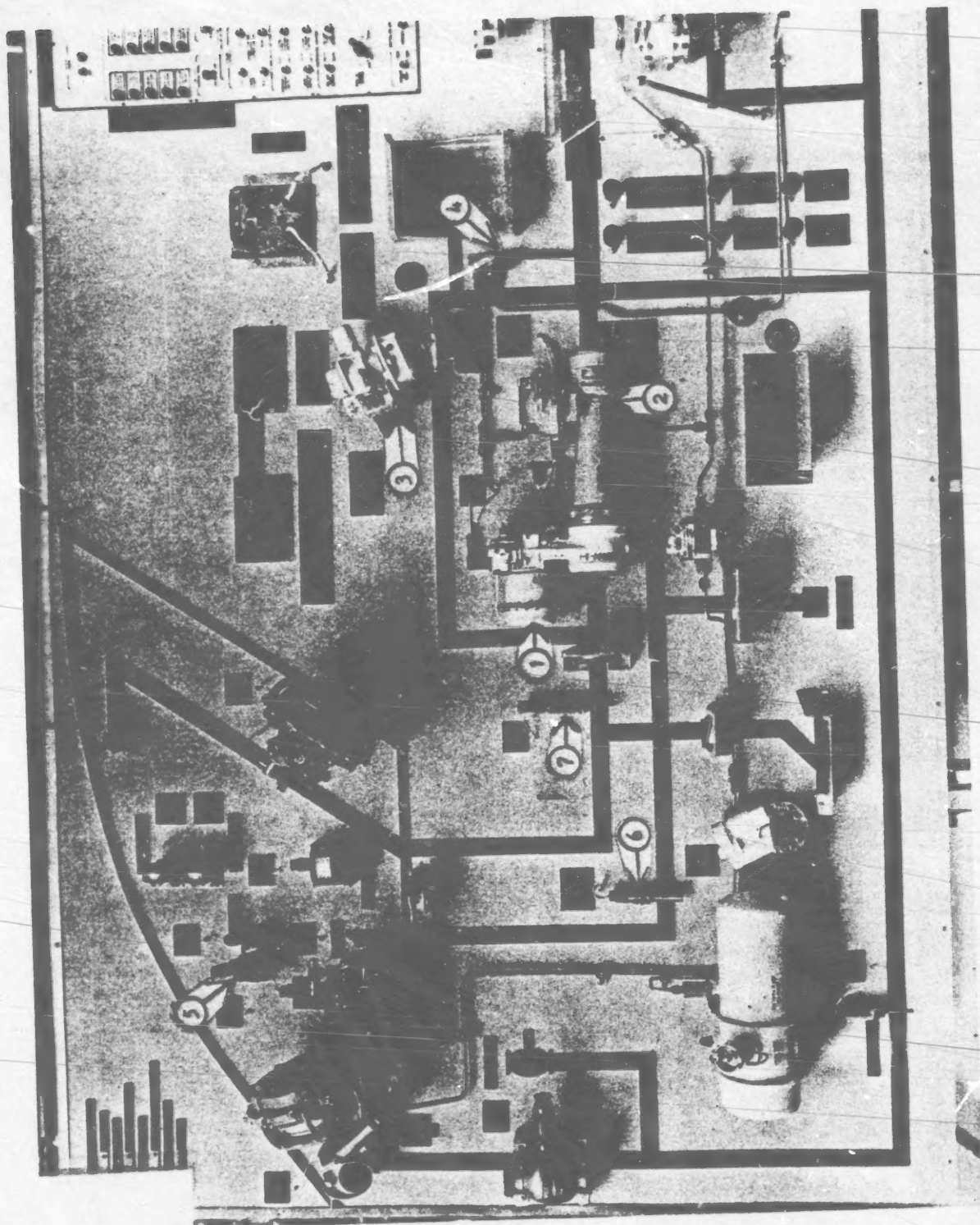


Figure 2.

2303

b. Using the trainer and figure 2, find each of the numbered parts. Write the number that goes with the name of each of these parts in the blank space to the left of the name. As you find these parts follow the flow of air through the hot and cold air systems.

1. _____ Hot air modulating valve.
2. _____ Minimum flow pressure switch.
3. _____ Rate-of-change sensor.
4. _____ Cabin overtemperature switch.
5. _____ Cabin temperature sensor and fan.
6. _____ Minimum upstream pressure regulator.
7. _____ Low limit sensor.

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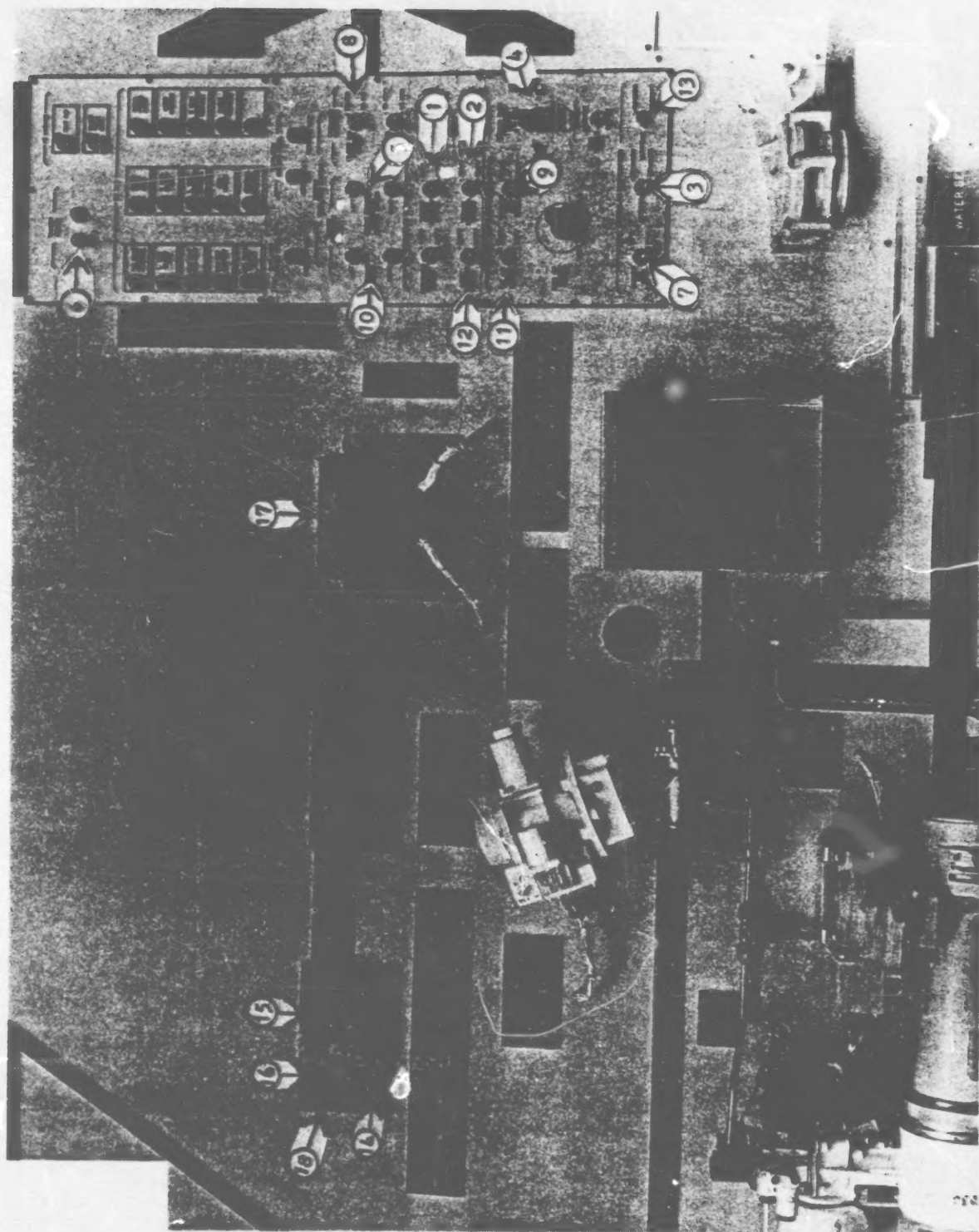


Figure 3.

2305

c. Using the trainer and figure 3, find each of the numbered parts. Write the number that goes to the name of each of these parts in the blank space to the left of the name.

1. _____ Air source switch.
2. _____ Trainer power switch.
3. _____ Engine start switches.
4. _____ Temperature selector.
5. _____ Simulator hot air temperature sensor switch.
6. _____ Airspeed switch.
7. _____ Simulator turbine bypass overtemperature switch.
8. _____ Engine starter cutout switches.
9. _____ Simulator cabin overtemperature switch.
10. _____ Simulator low limit temperature control sensor switch.
11. _____ Simulator bleed air pressure switch.
12. _____ Simulator turbine overtemperature switch.
13. _____ Mode selector.
14. _____ Simulator minimum flow pressure switch.
15. _____ Ambient air temperature switch.
16. _____ Temperature control box.
17. _____ Altitude switch.
18. _____ Temperature control panel.

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ANSWERS FIGURE 1

1. 2
2. 14
3. 3
4. 5
5. 11
6. 15
7. 6
8. 9
9. 12
10. 1
11. 4
12. 13
13. 10
14. 7
15. 8

ANSWERS FIGURE 2

1. 3
2. 2
3. 6
4. 7
5. 5
6. 1
7. 4

ANSWERS FIGURE 3

1. 15
2. 6
3. 10
4. 16
5. 11
6. 3
7. 1
8. 5
9. 12
10. 9
11. 8
12. 2
13. 14
14. 4
15. 7
16. 17
17. 13
18. 18

2307

Section 2. Operational check

a. The following section contains a list of switches, their location and the position the switches will be placed before you begin the operational check. After you have gone through the check and you understand how the system works, you will begin your troubleshooting.

POSITION SWITCHES AS FOLLOWS

SWITCH	LOCATION	POSITION
Trainer power switch	Top C/B panel	ON
Bleed air pressure switch	Simulator panel	> 30 psi
Turbine bypass overtemp switch	Simulator panel	< 170°F
Turbine overtemp switch	Simulator panel	< 350°F
Cabin overtemp switch	Simulator panel	< 250°F
Hot air temp sensor	Simulator panel	< 390°F
Low limit temp control sensor	Simulator panel	> -65°F
Minimum flow pressure switch	Simulator panel	> 15 ppm
Trouble switches	Left end of trainer	Down position
Circuit breakers	C/B panel	IN
Main landing gear switch	Simulation panel	Ground
Air source selector	A/C panel	OFF

RECHECK ALL SWITCH POSITIONS.

b. Be sure the air supply valve (behind the trainer) is turned full counterclockwise (open). Now do an operational check using the following procedures.

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SWITCH	OPERATING COMPONENT	RESULT OR POSITION
Ground air source switch ON		
Depress left engine start switch momentarily	Pressure regulating valve	Closed
	Hot air temp control valve	Closed
Depress left engine starter speed cutout switch momentarily	Pressure regulating valve	Open
	Hot air temp control valve	Open
The left engine is running so there is no need for the ground air source. The right engine will be started with bleed air from the left engine.		
Ground air source switch OFF		
Depress right engine start switch momentarily	Pressure regulating valve	Closed
	Hot air temp control valve	Closed
Depress right engine starter overspeed cutout switch momentarily	Pressure regulator valve	Open
	Hot air temp control valve	Open
Air source selector to BOTH	Left and right bleed air check and shutoff valves	Open
Mode switch to manual	Cabin temp sensor fan	On
For manual system operation the temperature rheostat is moved to the cool or warm position. The valves operate as long as the rheostat is held in the cool or warm position. The rheostat is spring loaded away from the manual positions. To operate manually the rheostat must be turned and held full clockwise or counterclockwise. When the cold air modulating valve moves toward the closed position, the air flow to the minimum flow pressure switch drops. This is simulated by moving the minimum flow simulation switch to less than 15 ppm after the cold air modulating valve has closed half way.		

SWITCH	OPERATING COMPONENT	RESULT OR POSITION
Move the temperature rheostat to warm and hold (move the minimum flow simulation switch to < 15 ppm after cold air mod valve closes 1/2 way)	Cold air mod valve Hot air mod valve	1/2 closed Open
With the hot air mod valve open and the cold air mod valve partially closed the cabin will receive warm air. Below 10 ppm the cabin temperature is controlled by the hot air modulating valve <u>ONLY</u>. The cold air mod valve is opened below 10 ppm to keep a supply of cool air going to the electronic equipment and cabin.		
Place minimum flow pressure simulator to < 10 ppm	Cold air modulating valve	Open
Move temperature rheostat to cold and hold	Hot air modulating valve	Closed
Move rheostat to warm and hold	Hot air modulating valve	Open
With the Mode switch OFF there is no power to the cold and hot air mod valve actuator and clutches. The cold air mod valve is spring loaded OPEN and the hot air mod valve is spring loaded CLOSED.		
Mode switch to OFF	Cold air modulating valve Hot air modulating valve	Open Closed
Minimum flow pressure simulator switch to > 15 ppm		
Place mode switch to AUTO (place minimum flow press switch to < 15 ppm after cold air modulating valve closes 1/2 way)	Cold air modulating valve Hot air modulating valve Cabin temperature sensor fan	1/2 closed Open ON
The temp selector is in the warm position and the mode switch in AUTO the cabin receives warm air.		
Move temperature rheostat to cool position	Hot air modulating valve Cold air modulating valve	Closed Open
The hot air mod valve CLOSED and the cold air mod valve OPENED so only cold air goes to cabin.		

SWITCH	OPERATING COMPONENT	RESULT OR POSITION
Minimum flow pressure simulator switch to > 15 ppm		
Move temperature rheostat to warm (place minimum flow pressure simulator switch to < 15 ppm after cold air modulating valve closes 1/2 way)	Cold air modulating valve Hot air mod valve	1/2 closed Open
Place minimum flow pressure simulator switch to < 10 ppm	Cold air mod valve Hot air mod valve	Open Open
When the air flow to the minimum flow pressure switch drops below 10 ppm, the cold air modulating valve OPENS. The temperature is controlled by the hot air modulating valve. This works the same in AUTO as it did in MANUAL.		
Move rheostat to cool position	Hot air mod valve	Closed
Move rheostat to warm	Hot air mod valve	Opens
Minimum flow pressure simulator switch to > 15 ppm (place minimum flow press switch to < 15 ppm after cold air modulating valve closed 1/2 way)	Cold air mod valve Hot air mod valve	1/2 closed Open
Cabin overtemp simulation switch to > 250°F	Hot air mod valve Cold air mod valve	Closed Open
The cabin over-temp thermostatic switch protects the ducting by keeping the temperature below 250°F.		
Minimum flow pressure simulation switch to > 15 ppm		
Cabin overtemp simulation switch to < 250°F (place minimum flow pressure simulation switch to < 15 ppm after cold air mod valve closes 1/2 way)	Cold air mod valve Hot air mod valve	1/2 closed Open

2311

SWITCH	OPERATING COMPONENT	RESULT OR POSITION
Place low limit temp control simulating sensor switch to < -650°F	Low limit temp control valve	Open
The low limit temperature sensor keeps the water separator from freezing by opening. The low limit temperature control valve directs 390°F air into the water separator to melt the ice.		
Place low limit temp control simulation sensor switch to > -650°F	Low limit temp control valve	Closes
When the ambient air reaches more than 75°F the CADC opens the ram air exit door. This causes more air to cross the air-to-air heat exchanger increasing the cooling capacity. Also if the aircraft air-speed is below 225 knots, more cooling is needed so the CADC will open the ram air exit door.		
Place ambient air simulator switch to > 75°F	Ram air exit valve	Open
Place ambient air simulator switch to < 75°F	Ram air exit valve	Closed
Place airspeed simulation switch to < 225 knots	Ram air exit valve	Open
Place airspeed simulation switch to > 225 knots	Ram air exit valve	Closed
If the pilot decides the air conditioning system is not putting out enough cool air (because of CADC failure) he can select override on the ram area switch. This OPENS the ram air exit door which lets more air cross the air-to-air heat exchanger.		

SWITCH	OPERATING COMPONENT	RESULT OR POSITION
Place ram area switch to OVRD (Override)	Ram air exit valve	Open
Place ram area switch to normal	Ram air exit valve	Closed
Place bleed air pressure simulation switch to < 30 psi and altitude simulation switch to < 10,000 ft.	Simulated turbine bypass	Open
During certain flight modes, such as landing the aircraft engines, are operated at a reduced power setting. This results in lower bleed air pressures in the bleed air manifold. To assure an adequate flow of air through the air conditioning system, the turbine bypass valve <u>OPENS</u> when bleed air pressure is below 30 psi <u>and</u> aircraft altitude is below 10,000 ft.		
Place bleed air pressure simulation switch to > 30 psi and altitude simulation switch to > 10,000 ft.	Simulated turbine bypass	Closed

Section 3. Troubleshooting

a. The AFTO Forms 781A and 349 will be filled out during troubleshooting. Get the forms from your instructor. The trouble switch numbers are placed in the discrepancy block. Put the corresponding trouble switch to the ON position on the trainer. Make an operational check and find the malfunction. Write the malfunction in the discrepancy block.

b. Troubleshoot the system and write the wire number or part that is bad in the corrective action block. Also, write the corrective action that would be taken to fix the malfunction. Fill in the following 781A blocks: SYMBOL, DATE DISCOVERED, WHEN DISCOVERED CODE, DISCREPANCY, DISCOVERED BY, CORRECTIVE ACTION, CORRECTED BY, and DATE CORRECTED.

c. When you have completed troubleshooting, have the instructor check your answers. The instructor will assign one of the problems on the 781A for completion of the AFTO Form 349. Turn the completed AFTO Forms 781A and 349 in to your instructor.

2313 Information necessary for the completion of APTO Form 349:

ITEM

JOB CONTROL NO.	1265578
WORK CENTER	M3360
I. D. NO/SERIAL NO.	MA 9767
PRI.	2A
LOCATION	B2
TYPE MAINT.	B
WHEN DISC.	In Flight-No abort

Environmental/Pneudraulic Branch
 Chanute AFB, Illinois

3ABR42331-WB-309B
 2 January 1979

FUNCTIONAL CHECK OF AIR CONDITIONING SYSTEM

OBJECTIVE

Using a schematic diagram, source of hot pressurized air, and the fighter/bomber environmental systems capsule, perform an operational check and troubleshoot the system locating the cause of 4 of 5 malfunctions given.

EQUIPMENT

CT-5 Trainer
 Ear Protectors

Basis of Issue
 1/4 students
 1/student

PROCEDURE

You are to make a functional check of an air conditioning system. This check is made to be sure that the parts in the system are operating normally. To help you do this, the instructor will have you use figure 1 to trace the flow of air through the system under various conditions.

Note: You will need to get in the cockpit of the trainer. Do not move the switches or controls unless directed to do so.
Remove all jewelry.

STEP 1:

Below is a list of controls and parts of the system. Get in the cockpit and use the list to find the parts. As each part is found, put a checkmark in the blank space.

- _____ 1. Temperature control panel. Look at the center console between the seats.
- _____ 2. Defog lever. Look on the right console.
- _____ 3. Air conditioning outlets. Look in the center and top of the cockpit and at about shoulder high on the outside of each seat.
- _____ 4. Ram air door. Look on the outside of the cockpit below the right hatch, near the steps.

STEP 2:

It's now time to prepare the capsule for an operational check. Follow the checklist below. Be sure to read each step carefully. As each step is completed, put a checkmark in the blank space.

- _____ 1. Locate the two electrical cords on the F-111 capsule. Plug these cords into the wall outlets.

Supersedes 3ABR42231-WB-311, 21 November 1975.

OPR: 3370 TCHTG

DISTRIBUTION: X

3370TCHTG/TTGU-P - 500; TTVSA - 1

Designed for ATC Course Use. Do Not Use on the Job.

- ____ 2. Locate the F-111 switch on the bleed air shutoff valve control panel. Place this switch to the closed position.
- ____ 3. Locate the F-111 power switch on the front of the trainer. Place this switch to the ON position.

Note: To perform an operational check on the air conditioning system we need a source of hot pressurized air. For this test we will use a MA-1A ground air cart.

- ____ 4. Go to room 108. Take a headset off the rack on the left side of the room.

SAFETY STEP: Due to excessive noise, ear protectors must be worn while operating the MA-1A.

- ____ 5. Locate the bleed air shutoff valve switch (above the window). Place this switch to the close position.
- ____ 6. Go outside and prepare the MA-1A for starting.
 - a. Check for fuel.
 - b. Remove the protective covering.
 - c. Check for oil.
 - d. Unwrap the ground hose and lay it out flat along the ground (pointed away from the control panel).
 - e. Connect the battery.
 - f. Open the vents. Make sure the limit switch on the front vent is in place.
 - g. Open the control panel.
 - h. Check the maintenance forms.
- ____ 7. You are now ready to "blow out the hose." This is done to insure no foreign matter is in the hose. Place your headset over your ears at this time.
 - a. Place the master run switch to the run position.
 - b. Place the start switch to the on position for about 10 seconds, then let go.
 - c. Place the output air switch to the on position when the output air light comes on.
- ____ 8. After about 30 seconds, place the output air switch to the off position.
- ____ 9. Now connect the hose to the receptacle on the wall,
- ____ 10. Once the hose is secured, step away from the hose and place the output air switch back to the on position.
- ____ 11. Go back to room 108 and place the bleed air shutoff valve switch to the open position. Also, place your headset back on the rack.
- ____ 12. Return to room 106 and place the F-111 switch to the open position.

- ___ 13. Remove one headset per person from the gray locker.
- ___ 14. You are now ready to begin the operational check.

STEP 3:

Table 1 is the operational checklist for the air conditioning system. It must be followed step-by-step. Use this checklist to make a functional check of the system.

STEP 4:

Now that you have made the functional check you should be familiar with the normal operation of the system. The instructor will now put some malfunctions in the system. Use table 1 and again make a functional check. This time you must correctly identify 4 of 5 malfunctions. When you find a problem, tell the instructor as to what it is and its most probable cause.

STEP 5:

Shutdown procedures:

- ___ 1. Place the F-111 switch to the closed position.
 - ___ 2. Place the F-111 power switch to the off position.
 - ___ 3. Unplug and stow your headset.
 - ___ 4. Go to room 108 and place the bleed air shutoff valve switch to the closed position.
 - ___ 5. Place a headset from room 108 over your ears.
 - ___ 6. Go outside to the control panel on the MA-1A.
 - ___ 7. Place the output air switch to the off position.
 - ___ 8. When the output air gage reaches zero, place the master run switch to the off position.
 - ___ 9. After the turbine stops spinning, close the vents.
- SAFETY STEP:** The outlet vent may still be HOT. Be careful when closing this vent.
- ___ 10. Unplug the battery.
 - ___ 11. Place the hose back in the original position.
 - ___ 12. Place the protective covering back over the MA-1A.
 - ___ 13. Go back to room 108 and return your headset to the rack.
 - ___ 14. Return to room 106 and wrap all electrical cords around the hook located in front of the capsule.
 - ___ 15. You are now ready to fill out your data collection forms. The instructor has listed on an AFTO Form 781A the malfunctions he/she had you troubleshoot earlier. Document one of these on an AFTO Form 349 and have the instructor check your entries.

TABLE I
OPERATIONAL CHECKLIST

STEP	CONTROL	POSITION	RESULT
1	AIR SOURCE SWITCH	Move to LEFT, RIGHT, then to BOTH	Airflow should come from the air conditioning outlets in EACH SWITCH position.
2	MODE SWITCH	Manual	
3	TEMPERATURE SELECTOR	Hold to the MANUAL WARM POSITION	Air from the air conditioning outlets should become WARM
4	TEMPERATURE SELECTOR	Hold to the MANUAL COOL POSITION	Air from the air conditioning outlets should become COOL
5	MODE SWITCH	AUTOMATIC	None
6	TEMPERATURE SELECTOR	AUTOMATIC WARM	Air from the air conditioning outlets should become WARM
7	TEMPERATURE SELECTOR	AUTOMATIC COOL	Air from the air conditioning outlets should become COOL
8	TEMPERATURE SELECTOR	As needed to obtain COMFORT in the CABIN	A COMFORTABLE TEMPERATURE should be maintained
9	AIR SOURCE SWITCH	RAM	COLD airflow to the CABIN should STOP. RAM AIR DOOR should OPEN
10	AIR SOURCE SWITCH	OFF	ALL air flow to the CABIN should STOP, RAM AIR DOOR should CLOSE.

NOTE

This completes the operational check. Place the following switches in the position listed

AIR SOURCE
SWITCH

OFF

RAM AIR EXIT
SWITCH

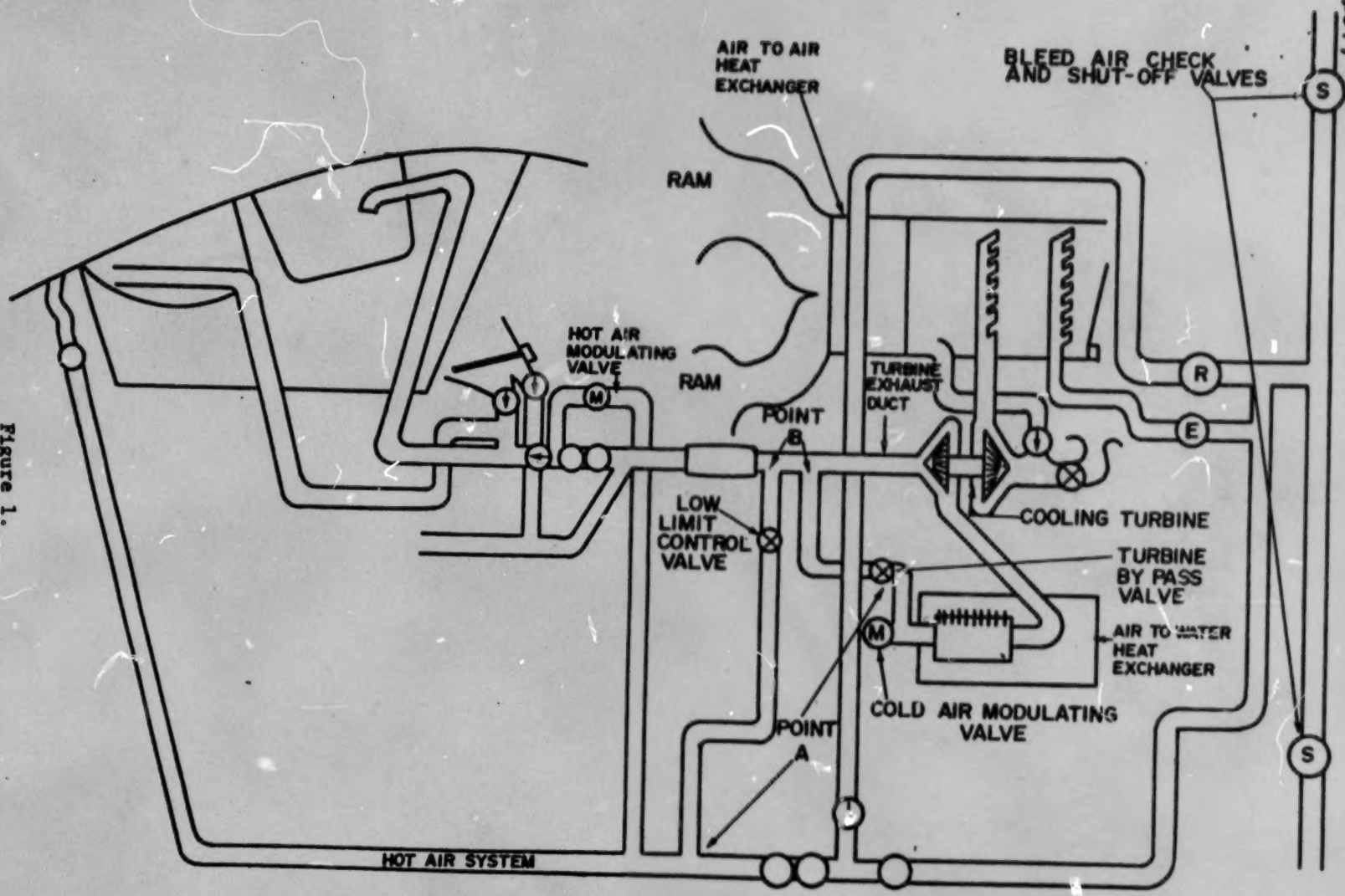
NORMAL

MODE SWITCH

OFF

Figure 1.

6





Technical Training

Aircraft Environmental System Mechanic

FIGHTER BOMBER WINDSHIELD CLEARING SYSTEM

16 January 1976



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

74 28406

This programmed text was designed for use in the 3ABR42231 course. The text has been validated using 32 students from the subject course. Ninety percent of the students taking this text surpassed the criteria called for in the approved lesson objectives. The average student required 3 hours to complete this lesson.

OBJECTIVES

After completion of this programmed text, you will be able to:

1. Identify windshield clearing system components and their function.
2. Explain operation of the
 - a. right and left rain removal valves.
 - b. ejector valve.
 - c. overheat thermal switch.
3. Explain operation of the
 - a. right and left windshield wash shutoff valve.
 - b. pressure regulating valve.

Standard of performance:

Correctly identify purpose and function of system components with 70% accuracy.

INSTRUCTIONS

This programmed text gives information in small steps called "frames." After each frame you are asked to complete a statement or determine the answer to a question. Read the material presented and make your response as directed. **DO NOT MARK IN THIS TEXT.** After you have made your response, compare your answer with the correct answer given above the following frame. If necessary, you may go back to check information previously given, but do not skip ahead.

Supersedes 3ABR42231-PT-310, 3 August 1973.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 1

The windshield clearing system is made up of two small systems; (1) the rain removal system and (2) the windshield wash system. The rain removal system will keep the windshield free of rain so the pilot's view is not obstructed. The windshield wash system is used to remove film, insects, and foreign material. In this text each system will be discussed separately, then how they work together.

Answer the statements as true (T) or false (F).

- ___ 1. Two smaller systems make up the windshield clearing system.
- ___ 2. The rain removal system keeps the windshield free of rain.
- ___ 3. Insects on the windshield are removed by the windshield wash system.

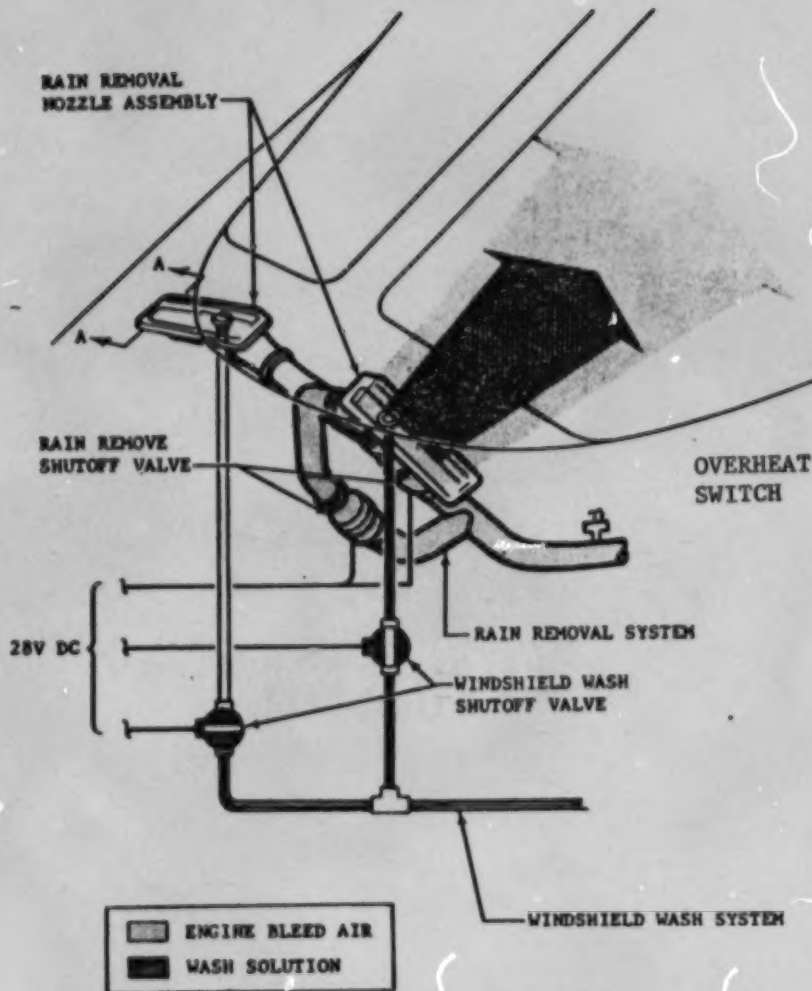
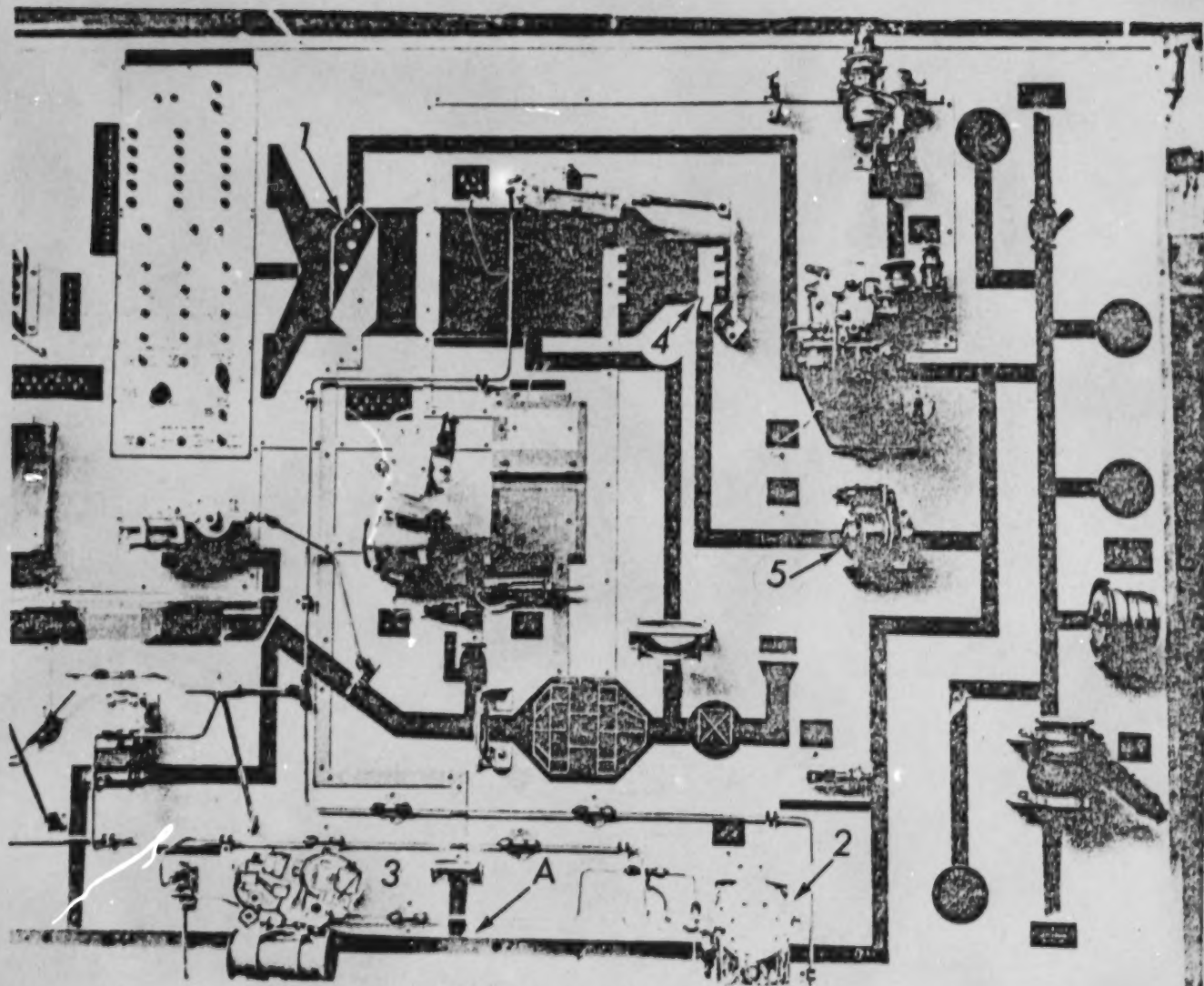


Figure 1.

The rain removal system directs a blast of hot air over the windshield. The hot air is sent through ducts to two rain removal shutoff valves. When these valves are opened, air is directed through fixed nozzles. The nozzles are found at the front of each windshield, figure 1. The rain removal nozzles have long slots. These slots discharge air in an upward direction across the windshield. The slots are open and will collect rain when the system is not in operation. A gravity water drain is put in the nozzles to keep water from accumulating in the air supply ducts and nozzle assembly. The water drain has a spring type diaphragm that will shut off during nozzle operation. This is to stop hot air leakage.

Complete the statements.

1. Air for rain removal is taken from the _____ system.
2. There are _____ rain removal shutoff valves.
3. The _____ receive air directly from the rain removal shutoff valves.
4. The drain assembly is _____ operated.



4. Gravity

Frame 3

Look at figure 2. Air for rain removal comes from the hot air system. The hot air system temperature is controlled at 390°F. Temperature is controlled by a mix of cool air from the air-to-air heat exchanger (1) with hot air from the hot air temperature control valve (2) at point A. This air is kept at a pressure of 45 psi by the hot air pressure regulator (3). When the rain removal system is operated, a large flow of air is required to maintain 45 psi and control the temperature at 390°F. This will cause an additional demand on the air-to-air heat exchanger to cool the air. To fix this problem an additional set of ejector nozzles (4) and an ejector valve (5) are used. When the rain removal system is turned on the ejector valve will open. Air will pass through the ejector nozzles and make a low pressure area in the ram air duct. The low pressure area is downstream of the heat exchanger. The result is an increase in ram air flow across the heat exchanger.

Complete the statements.

1. The ejector valve will increase the effectiveness of the _____.
2. The _____ is open during rain removal operation.
3. The temperature of the air used for rain removal is _____.
4. The pressure of the air used for rain removal is _____.

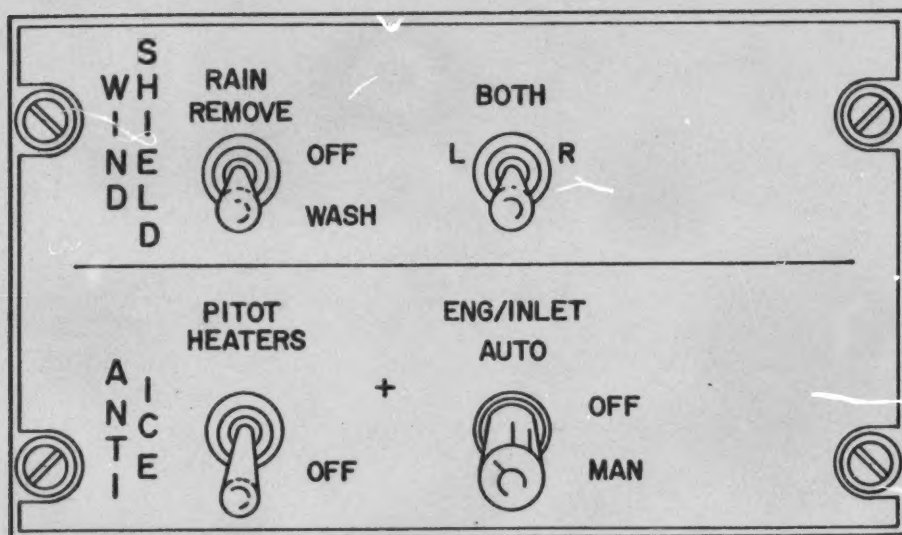


Figure 3.

3. 390°F 4. 45 psi

Frame 4

There are two rain removal valves and a bleed air ejector valve. The three valves are solenoid controlled, pneumatically actuated shutoff valves. They are opened by placing the windshield selector switch (figure 3) to the L (left), R (right), or BOTH positions. The rain removal switch must be in the RAIN REMOVAL position for the system to work. When the rain removal switch is in RAIN REMOVAL, the solenoids of the rain removal shutoff valves and the bleed air ejector shutoff valve are energized. This will cause the valves to open pneumatically. The rain removal shutoff valves can be closed in two ways. The first way is to place the rain removal valve switch to the OFF position. This will also close the bleed air ejector valve. The other way is by the windshield thermal overhear switch. The switch is normally open and is found in the hot air supply duct. It is upstream of the rain removal shutoff valves. When in normal operation and the air temperature gets above 445°F, the windshield thermal overhear switch will close. This will cause the overhear relay to energize and the WINDSHIELD HOT lamp in the cockpit will light. The solenoids of the rain removal valves will be deenergized and cause the valves to close. When there is an overhear condition, the bleed air ejector valve will stay open. This will cause greater cooling through the air-to-air heat exchanger. The purpose is to return the hot air system temperature to normal. When the temperature drops below 445°F the rain removal system will work normally again.

Answer the statements as true (T) or false (F).

- ___ 1. The rain removal shutoff valves are opened by the WINDSHIELD CLEAR BUTTON.
- ___ 2. There are two means of closing the rain removal shutoff valves.
- ___ 3. The secondary means of closing the rain removal shutoff valves is to place the rain removal switch to OFF.
- ___ 4. The overhear switch sends power to close the rain removal shutoff valves at 390°F.

2329

CORRECT RESPONSES TO FRAME 4: 1. F 2. T 3. F 4. F

Frame 5

The second part of the windshield clearing system is the windshield wash system. The windshield wash system will operate during landing, takeoff, and when the aircraft is waiting for takeoff. The windshield wash and rain removal systems must not be used at supersonic speeds. Poor air conditioning and overtemperature conditions could exist due to high bleed air temperatures.

Answer the statements as true (T) or false (F).

1. The windshield wash system is designed for operation during takeoff.
2. The wash system may be operated at any time.
3. The windshield wash is a part of the windshield clearing system.

Both the windshield wash and rain removal systems are used to wash the windshield. The windshield wash system will send the wash solution to the windshield at 15 psi pressure. This pressure will not be enough to force the solution over the entire windshield. Pressure from the rain removal system is used. A blast of 45 psi of hot air from the rain removal nozzles will force the solution over the whole windshield. The mix of the hot air and wash solution will make the cleaning action.

Answer the statements as true (T) or false (F).

- ____ 1. The windshield wash system does operate with the rain removal system.
- ____ 2. A flow of air across the windshield wash nozzles draws the wash solution onto the windshield.
- ____ 3. The windshield wash system needs the air used for rain removal for operation.
- ____ 4. The rain removal system and windshield wash system operate at the same time.

CORRECT RESPONSES TO FRAME 5: 1. T 2. F 3. TCORRECT RESPONSES TO FRAME 6: 1. T 2. T 3. T 4. T

Frame 7

Look at figure 4. The wash solution is stored in a one gallon tank. To force the solution to the windshield wash nozzles, pressure is applied to the top of the solution in the tank. Air for head pressure is taken downstream of the service air-to-air heat exchanger. This air is regulated to 15 psi by a pressure regulating valve. The air goes through a check valve (A) and to the wash solution tank. A 20 psi safety relief valve (B) will keep pressure from building up too high, should the pressure regulator fail. The washing action is caused by selecting L, R, or BOTH on the windshield selector switch. The rain removal switch must also be placed in the wash position. When this happens, 28V DC is sent to the windshield wash shutoff valves (C) and the rain removal shutoff valves that will cause them to open. Once either or both of the windshield wash valves are open, the head pressure forces the wash solution through tubing to the nozzles. The 45 psi used for rain removal will then force the wash solution on the windshields for cleaning. When the rain removal switch is put to WASH, a time delay relay is energized. This timer allows the windshield wash system to operate for 5 seconds. If the pilot wants more cleaning, the rain removal switch must again be put to the WASH position.

Answer the statements as true (T) or false (F).

1. The wash solution is stored in a one gallon tank.
2. The head pressure of the tank is normally 15 psi.
3. Only one side of the windshield can be cleared at a time.
4. The 45 psi used for rain removal is also used with the windshield wash system.
5. The timer relay allows the windshield wash system to operate for 5 seconds.

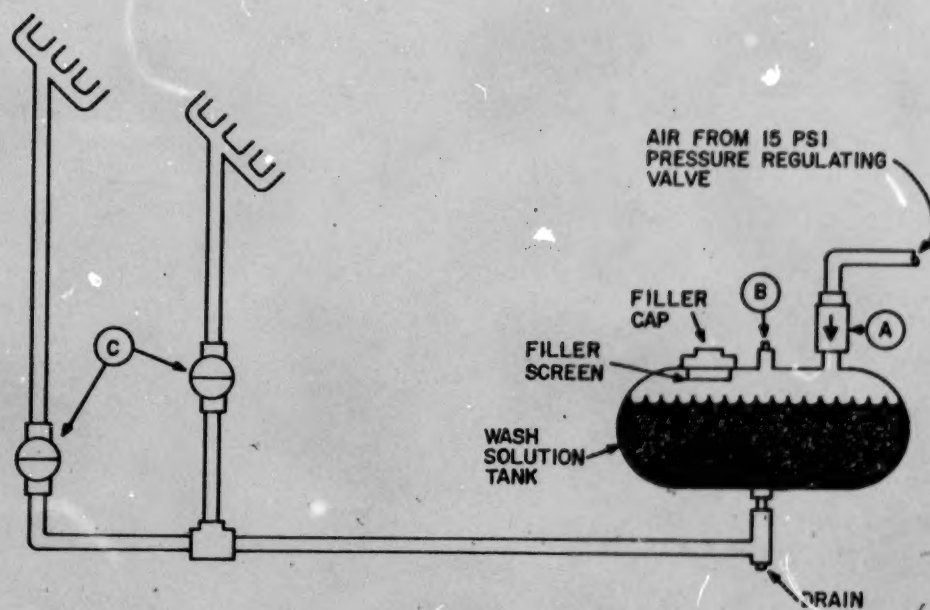


Figure 4.

CORRECT RESPONSES TO FRAME 7: 1. T 2. T 3. F 4. T5. T

Frame 8

The windshield selector switch will allow the selection of L, R, or BOTH windshields for wash or rain removal. The rain removal and windshield wash valves are energized open. When the selector switch is put to the L position (figure 5A) a cam on the bottom of the switch is forced to the left. This will open the contacts for power to the right rain removal and windshield wash valves. The same procedure happens when R is selected (figure 5B). When BOTH is selected (figure 5C) the cam will stay in a neutral position and will allow the circuits for both rain removal shutoff valves to be completed.

Answer the statements as true (T) or false (F).

1. Positioning the windshield selector switch to R breaks the power circuit to the left windshield wash and rain removal valve.
2. Positioning the windshield selector switch to BOTH breaks the power circuit to the left and right windshield wash and rain removal valves.
3. Positioning the windshield selector switch to the L position completes the circuit for the left windshield wash and rain removal valves, when the rain removal switch is in rain removal.

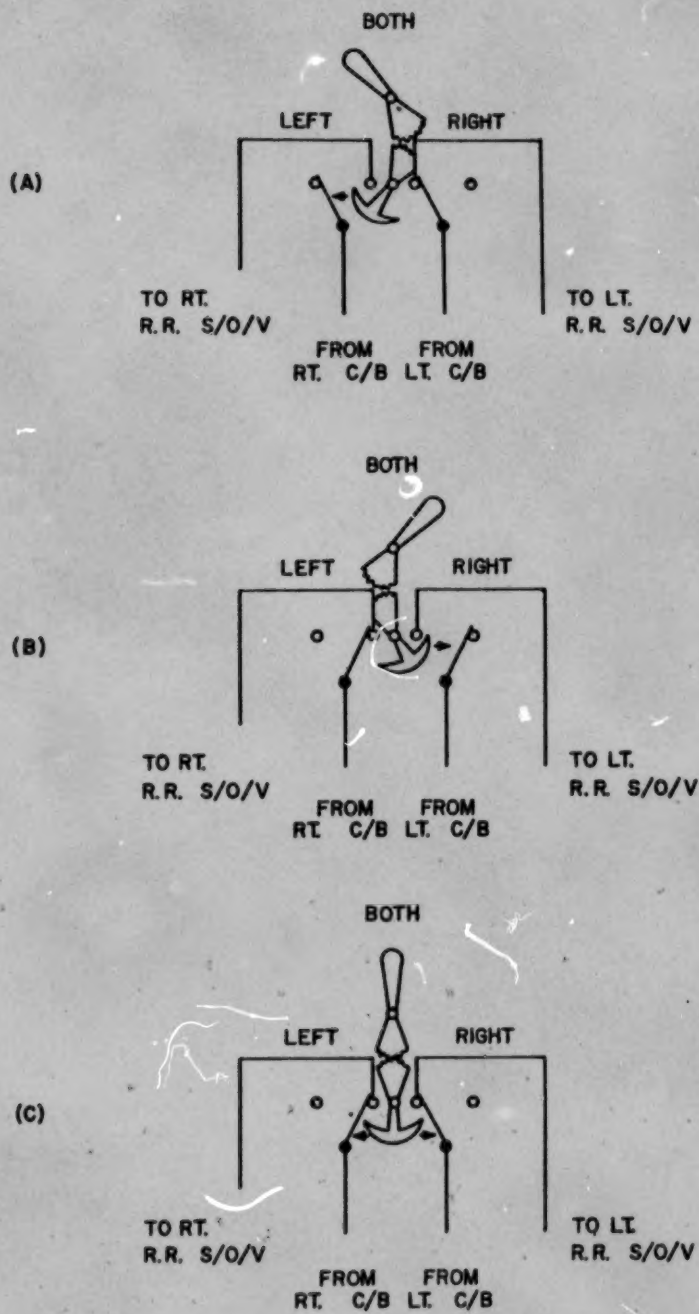


Figure 5.

FIGHTER BOMBER WINDSHIELD CLEARING SYSTEM

Frame 1

1. _____ 3. _____

2. _____

Frame 5

1. _____ 3. _____

2. _____

Frame 2

1. _____

2. _____

3. _____

4. _____

Frame 6

1. _____ 3. _____

2. _____ 4. _____

Frame 7

1. _____ 4. _____

2. _____ 5. _____

3. _____

Frame 3

1. _____

2. _____

3. _____

4. _____

Frame 8

1. _____ 3. _____

2. _____

Frame 4

1. _____ 3. _____

2. _____ 4. _____

FIGHTER/BOMBER WINDSHIELD CLEARING SYSTEM

OBJECTIVE

Given a wiring diagram and a workbook covering the rain removal and windshield wash system, determine operation by tracing circuits and analyzing selected malfunctions. From a list of statements and responses, select 70% of the responses correctly.

EQUIPMENT

Box of colored pencils

Basis of Issue
1/student

PROCEDURE

Turn to foldout 1. This is the wiring diagram of the windshield clearing system. Use the colored pencils and the instructions given in each step to trace the circuits. Foldout 1 will be used for each step in the project.

Step 1

Use a red pencil to trace the following circuits. Start at CB10, and trace wire H401A22 to pin H on the control panel. From there, trace the wire to junction U. At junction U the circuit parallels to 4 on the right windshield selector switch and to X1 of the XK1 relay. This is the CB10 circuit. Start at CB11 and trace wire H402A22 to pin J on the control panel. From there, trace the wire to 3 on the left of the windshield selector switch, and stop. This is the CB11 circuit. Start at CB12 and trace wire H400A22 to pin A of the windshield over-heat thermal switch. Go to CB12 again and trace wire H400B22 to pin K of the control panel. From there, trace this wire to A2 of the XK2 relay. This completes the main "power" circuits (CB10, CB11, CB12).

Step 2

The reason for not tracing to the coil of the XK1 relay is because the coil does not normally have a ground. XK1 relay has a ground just when the TD relay is energized. This ground wire goes to the relay and is hooked to a box marked TD. Another wire comes out of this box and then goes to F2. TD is for "TIME DELAY". The "TIME DELAY" circuit is just closed for 5 seconds. For the time this circuit is in operation, the switch below the coil is pulled to the right to make a circuit through the coil to X2 and then to ground. This action will make a ground for the coil. The power that was

OPR: TAS

DISTRIBUTION: X

TAS - 500; TTVGC - 1

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2337

at X1 now has a ground and will energize the coil that will draw the upper contacts down. After 5 seconds the switch moves to its original position and again the coil has no ground. The contacts above the coil will also move back to their original positions. This 5 second delay is used to control the windshield wash cycle.

Step 3

The next circuit is for rain removal action over both windshields. Use a blue pencil to trace this circuit. The power circuits have already been traced to 3 and 4 of the windshield selector switch. Trace from 3 through the switch to the wire junction. From the junction trace to the right of A2 and B2 of relay XK1. Relay XK1 is deenergized. Go back to the junction and trace to the left and to the next junction. From this junction follow the wire through the coil of relay XK3. Show the contacts energized. From the last junction traced, go to the left and show power at the lower contact of the windshield and rain removal switch. The rain removal switch has been placed to RAIN REMOVE. Power goes through the lower switch to the upper contact and then to the second junction. From this junction, power goes to the left to contact A1. Keep in mind, XK3 relay has been energized, so draw in the circuit from A1 to A2. From there, trace to the bleed air ejector valve and then to ground. Return to the junction connected to A1. Go up a little, to find another junction. From here trace power to B2 of relay XK2. Since this relay is not energized, trace power to B3 of relay XK2 and then to P of the control panel. From here trace power to the right rain removal shutoff valve and then to ground. The right rain removal shutoff valve is now open.

Step 4

The circuit through the left windshield selector switch has been drawn. Trace power from 4 on the right windshield selector switch to the wire junction. Go to the right and show power at switches C2 and D2 of the XK1 relay. Go back to the junction and trace to the left and to the upper contact of the rain removal switch. The rain removal switch is in RAIN REMOVE, so trace to the upper contact. From here trace to the first junction and down to the next junction. From here to the right and to the left rain removal shutoff valves, and then to ground. The left rain removal shutoff valve is now open. This completes the entire circuit when the rain removal switch is placed to RAIN REMOVE and the windshield selector switch is placed to BOTH.

Step 5

The following circuit will show how both windshields are washed. Use a GREEN pencil to trace this circuit. The power circuits (in red) have been traced to 3 and 4 of the windshield selector switch. Start at 3 of the left switch, trace to the wire junction. From the wire junction, go to the right and show power at A2 and B2 of the XK1 relay. Go to the left of the junction to the next junction. From this point, trace the wire that goes down. Trace it to the coil of the XK3 relay and then to ground. Draw the contacts down. Go back

to the last junction and continue to the left to the windshield wash and rain removal switch. For the circuit to wash both windshields, trace from the lower switch to the lower contact, from the lower contact to B1 of the XK3 relay. This relay is energized. Trace from B1 to B2 of the XK3 relay. From XK3 relay to F2 of the XK1 relay. Keep in mind what the TD represents. If not, go back and refresh your memory. From F2 of XK1, power will go in the box marked TD, then out the other side to X2 and then to ground. This is the time delay circuit that holds for 5 seconds. Circuit power can now go from X1 of the XK1 relay through the coil to ground. This action energizes the XK1 relay.

Step 6

With the XK1 relay energized, the contacts are forced down. Power that is at A2 and B2 can now cause current to flow. Trace from A2 to A1 and from A1 to M of the control panel, then to the right windshield wash shutoff valve and to ground. Trace from B2 to B1 of the XK1 relay, then from B1 to the first junction. From the junction trace to the left to A1 of the XK3 relay. This relay is energized. Go from A1 to A2 to G of the control panel. From G, trace to the bleed air ejector valve then to ground. Go back to the last junction that led to A1 of the XK3 relay. From here go up to the next junction. From this junction go to the right to B2 of the XK2 relay. This relay is not energized. Go from B2 to B3 then on to P of the control panel. From P of the control panel, trace to the right rain removal shutoff valve then to ground. This completes the circuit just for the right side.

Step 7

Now trace the circuit that will show operation of the left side of the rain removal system. Start at 4 and trace through the right switch, down to the first junction. From the junction go down to C2 and D2 of the XK1 relay. The coil of this relay is energized. Trace from C2 to C1 and to the next junction. From this junction go to the right to C2 of the XK2 relay. This relay is not energized. Trace from C2 to C3 then to N of the control panel. From N, trace to the rain removal shutoff valve and to ground. Go back to D2 of the XK1 relay and trace from D2 to D1 and then to L of the control panel. From L, trace to the left windshield wash shutoff valve. This circuit is now complete. Both windshields are now being washed. Keep in mind, the time delay (TD) of the XK1 relay is just for 5 seconds. When this time is up, the coil of the XK1 will not have a ground. With no ground the relay deenergizes and pushes the contacts up. This action: (a) closes the right windshield wash shutoff valve; (b) closes the right rain removal shutoff valve; (c) closes the left rain removal shutoff valve and (d) closes the left windshield wash shutoff valve.

3339

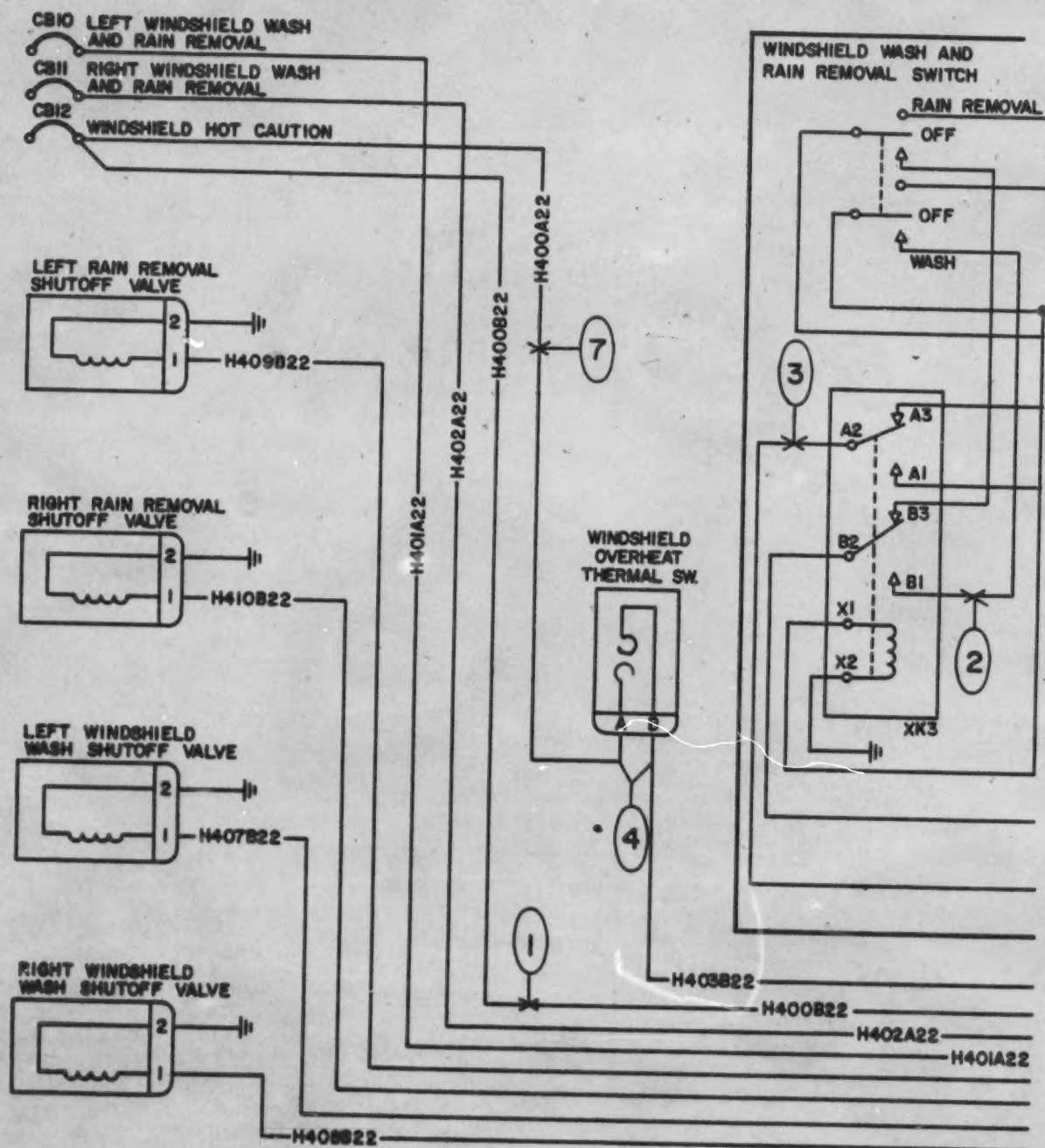
Step 8

Both the windshield wash and the windshield rain removal systems are on the wiring diagram. The last circuit that will be shown is the windshield overheat circuit. Use a black pencil for this circuit. If the temperature of the air is more than 445°F, due to too much hot air in the supply system, then the normally open windshield overheat thermal switch will close. This action will make a circuit from B of the overheat switch to the coil of XK2 relay. When this happens the contacts are pulled down. This breaks the circuit to the right rain removal valve at B3 of the XK2 relay. Energizing this relay will also cut power to the left rain removal shutoff valve. The energized relay will also complete a circuit from A2 to A1 of the XK2 relay, to the WINDSHIELD HOT caution light in the cockpit. When the temperature of the air is less than 445°F, the thermal switch opens. The system returns to normal operation.

Step 9

There are 10 circled numbers on foldout 1 that indicate opens or shorts in a circuit. Below are 10 statements of troubles in the windshield clearing system. Read the statement and select the trouble number that could cause the conditions given.

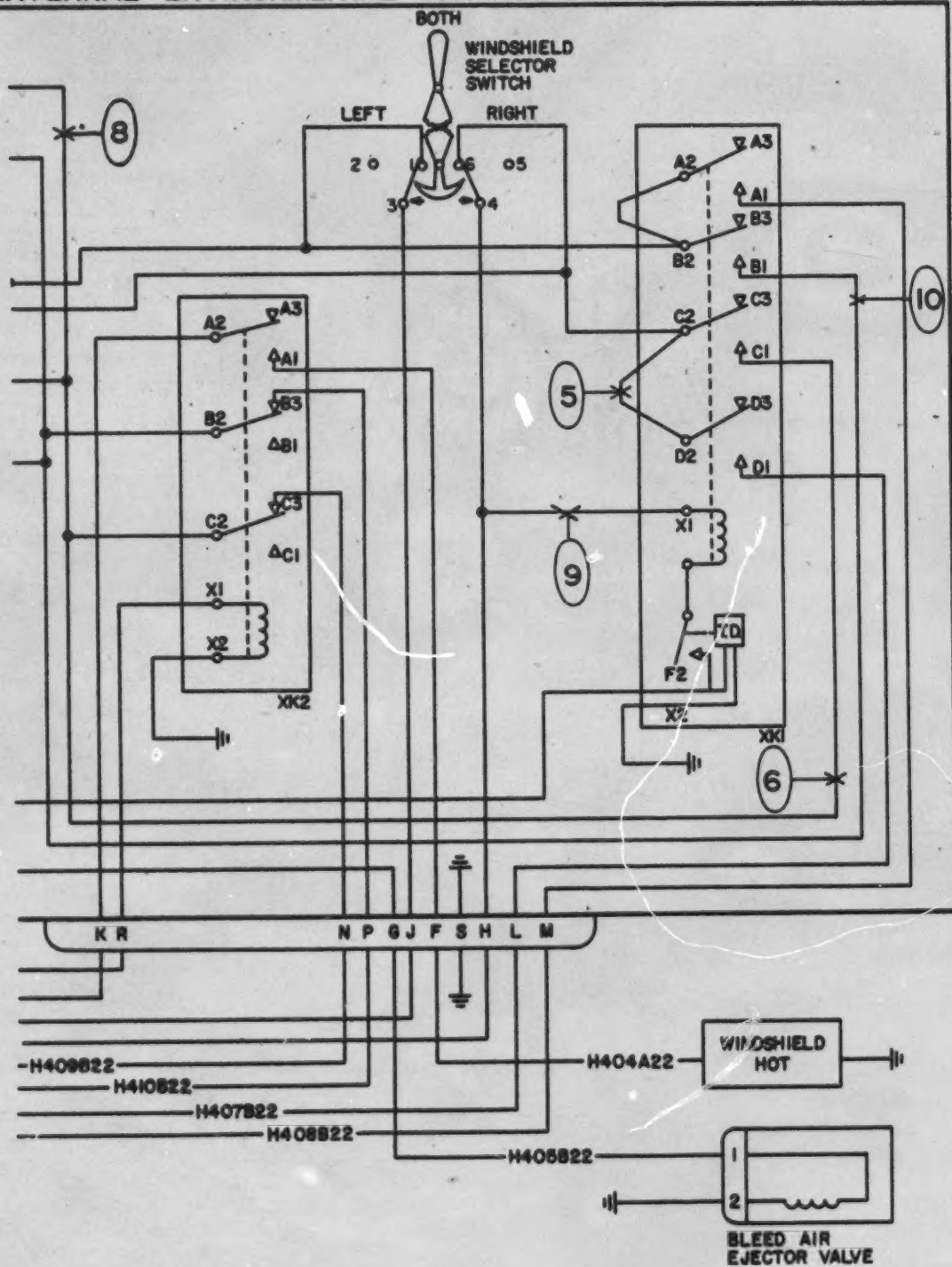
1. _____. Windshield wash system inoperative.
2. _____. Left rain removal shutoff valve and bleed air ejector valve will not work when rain removal is selected.
3. _____. Bleed air ejector will not work in left rain removal.
4. _____. Left windshield wash valve inoperative.
5. _____. Windshield hot light will not work in an overheat condition.
6. _____. Rain removal system is inoperative and hot light remains on at all times.
7. _____. Bleed air ejector valve and right rain removal shutoff valve remain open when wash is selected.
8. _____. Rain removal shutoff valves remain open during overheat and windshield hot light will not illuminate.
9. _____. Left rain removal shutoff valve and bleed air ejector valve will not work when windshield wash is selected.
10. _____. Time delay relay is inoperative during right windshield wash.



Foldout 1. Section 1.

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EXTERNAL ENVIRONMENTAL CONTROL PANEL



Foldout 1. Section 2.

5

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76-38334

Technical Training**Aircraft Environmental System Mechanic****ADVANCED FIGHTER-BOMBER WINDSHIELD CLEARING SYSTEM****5 September 1978**

**CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois**

**DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB**

2343

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

3ABR42331-WB-311

ADVANCED FIGHTER-BOMBER WINDSHIELD CLEARING SYSTEM COMPONENT IDENTIFICATION, OPERATIONAL CHECK AND TROUBLESHOOTING

OBJECTIVE

Using a wiring diagram and multimeter, perform an operational check and troubleshoot malfunctions on the fighter/bomber windshield clearing system trainer locating the cause of 4 of 5 malfunctions given.

EQUIPMENT

	Basis of Issue
Trainer 4024, Advanced Fighter-Bomber Air Conditioning System	1/student
Multimeter	1/student
Wiring Diagram, Windshield Clearing System	1/student
Trainer CT-5, F-111 Capsule	1/4 students

PROCEDURE

1. REMOVE ALL JEWELRY. Report to the laboratory instructor and tell him of the lesson you are working on. The instructor will have the necessary materials and trainer for your use.
2. This workbook is in five sections:
 - I. Location and identification of system components.
 - II. Windshield clearing system operational check.
 - III. Troubleshooting (trainer).
 - IV. Troubleshooting (capsule).
 - V. Documentation.

SECTION I

LOCATION AND IDENTIFICATION OF COMPONENTS

1. Using the trainer and figure 1, find each of the lettered parts. Write the number that goes with the name in the blank spaces.
 - a. _____ Air source switch.
 - b. _____ Windshield rain removal switch.
 - c. _____ Windshield overheat simulation switch.
 - d. _____ Windshield hot simulation light.
 - e. _____ Windshield anti-ice control panel.
 - f. _____ Windshield selector switch.

Supersedes 3ABR42231-WB-310, 1 December 1975, which may be used until existing stocks are exhausted.

OPR: 3370 TCHTG

DISTRIBUTION: X

3370TCHTG/TTGU-P - 500; TTVSA - 1

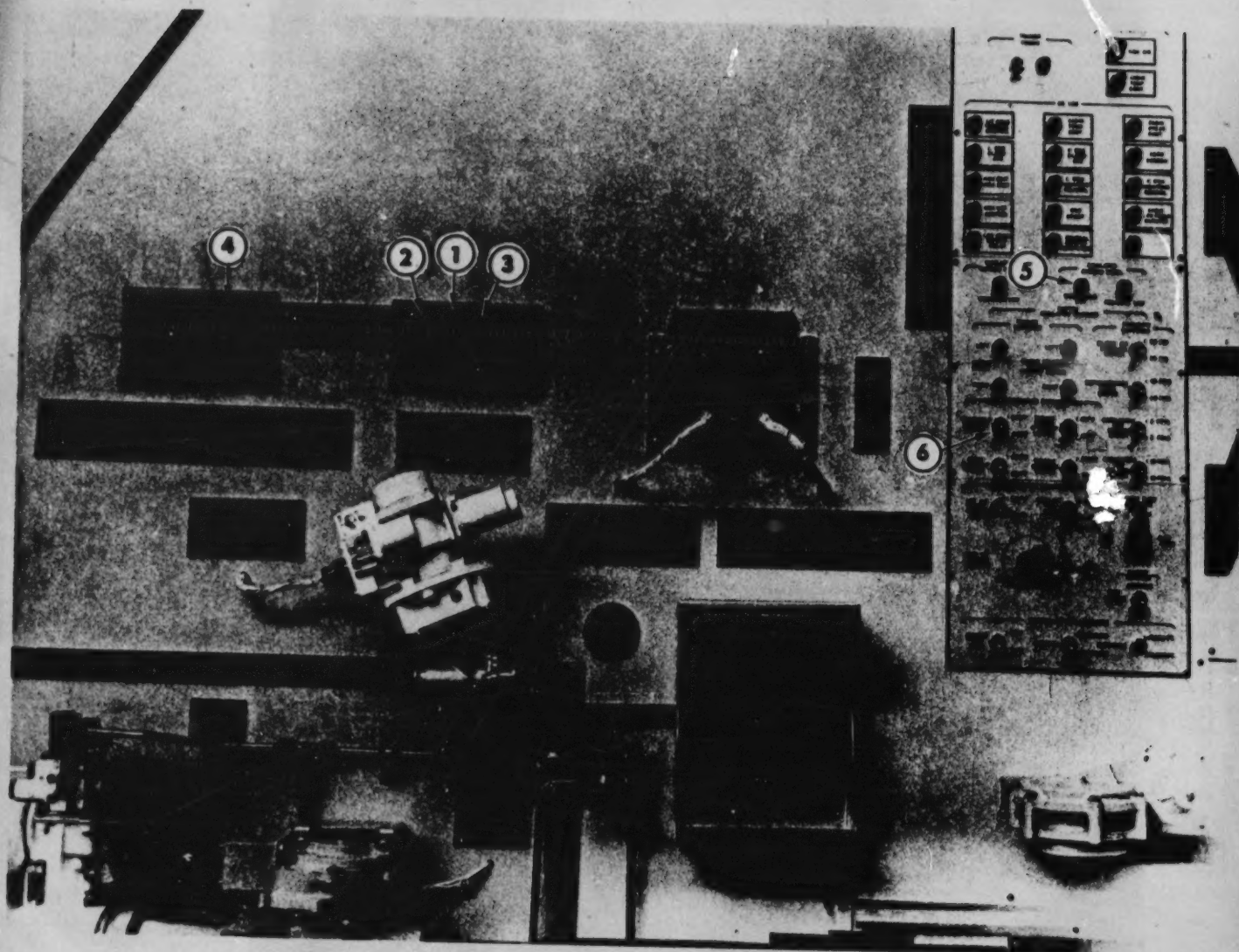


Figure 1.

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2. Using the trainer and figure 2, find each of the lettered parts. Write the number that goes with the name in the blank space.

- a. _____ Right windshield wash SOV.
- b. _____ Left windshield wash SOV.
- c. _____ Right rain removal SOV.
- d. _____ Left rain removal SOV.
- e. _____ Windshield overheat sensor.
- f. _____ Fixed nozzles.

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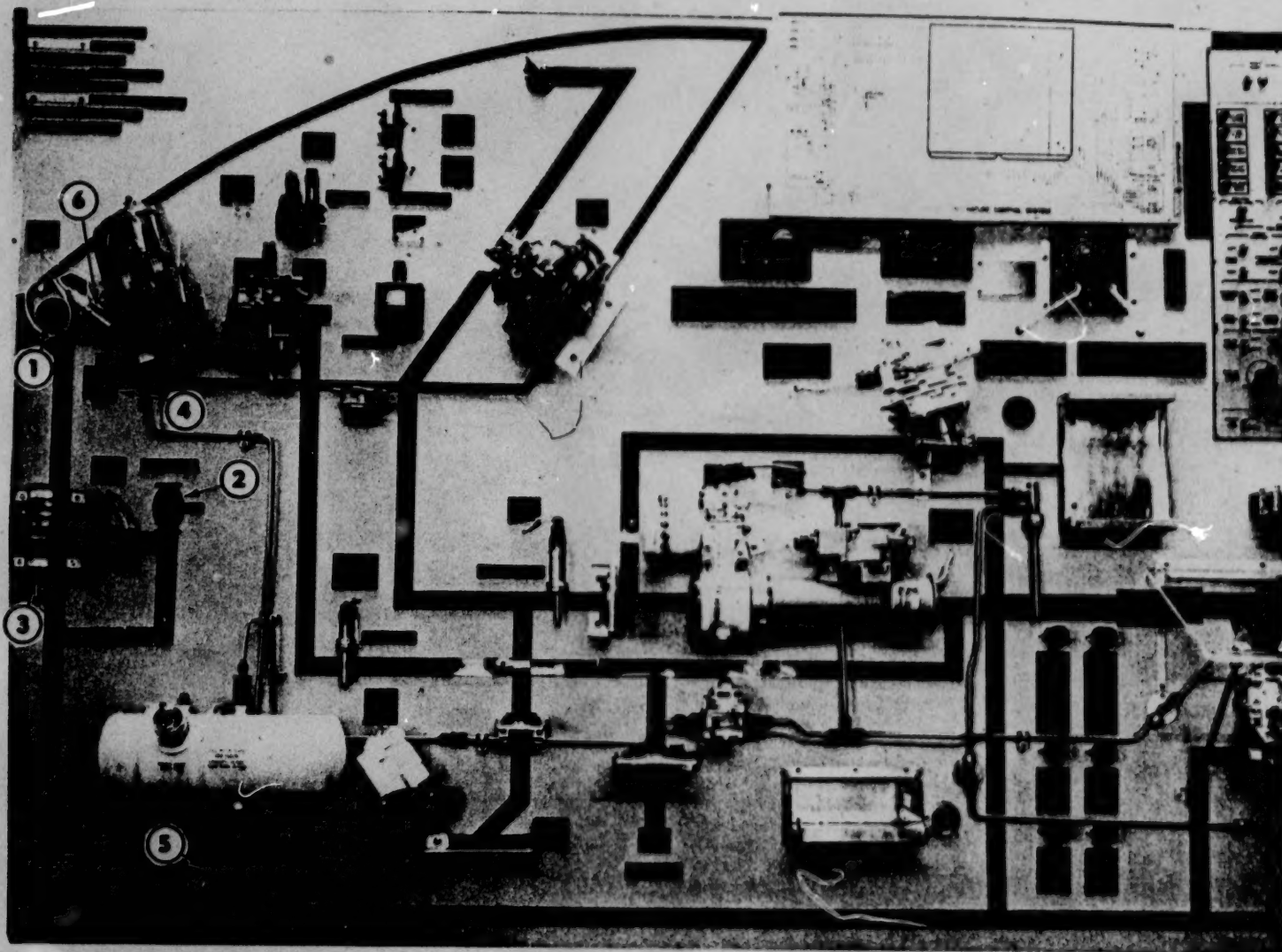


Figure 2.

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3. Using the trainer and figure 3, find each of the lettered parts. Write the number that goes with the name in the blank space.

- a. ___ Ejector valve.
- b. ___ Hot air pressure regulator.
- c. ___ Hot air temperature control valve.
- d. ___ Hot air temperature sensor.
- e. ___ Ejector nozzle.

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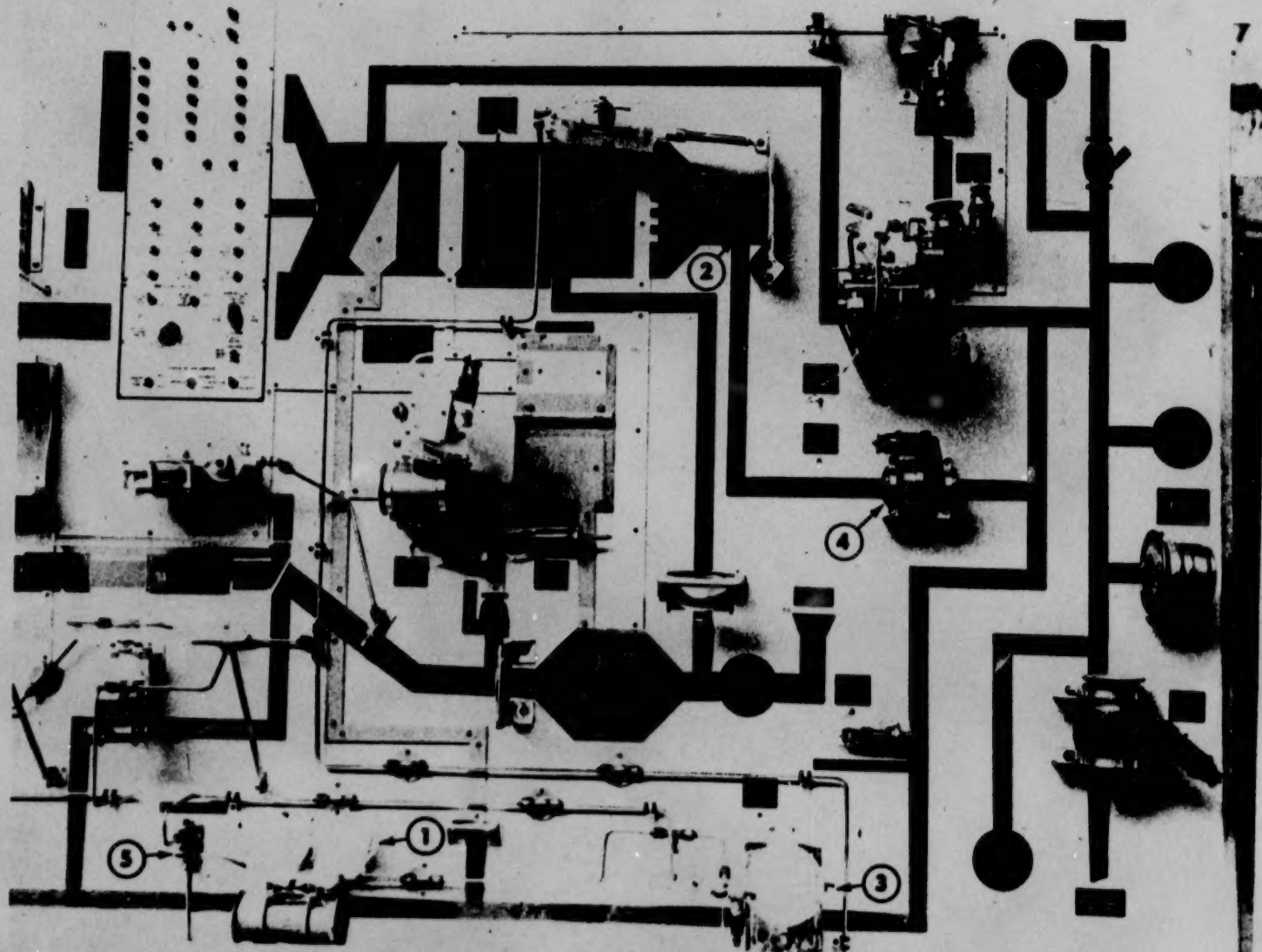


Figure 3.

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Answers, Figure 1.

- a. 4
- b. 2
- c. 6
- d. 5
- e. 1
- f. 3

Answers, Figure 2.

- a. 4
- b. 6
- c. 2
- d. 3
- e. 5
- f. 1

Answers, Figure 3.

- a. 4
- b. 1
- c. 3
- d. 5
- e. 2

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SECTION II

WINDSHIELD CLEARING SYSTEM
OPERATIONAL CHECK

PROCEDURE

Follow the step-by-step procedure for operating the windshield clearing system. Be sure to do each step as told. If you can not do the steps tell the instructor.

1. Preparation

- a. Find the wall locker in the F-111 laboratory. Get the windshield clearing wiring schematic and a multimeter from the locker.
- b. Connect the trainer electrical leads, located on the left end of the trainer, to the wall receptacles behind the trainer.
- c. Turn on the trainer air source located behind trainer.
- d. Push in all the trainer circuit breakers.

POSITION THE SWITCHES AS FOLLOWS

SWITCH	LOCATION	POSITION
Trainer switch	Top C/B panel	ON
Circuit breakers	C/B panel	IN
Turbine bypass overtemperature	Simulator panel	< 170°F
Turbine overtemperature switch	Simulator panel	< 350°F
Windshield overheat switch	Simulator panel	< 445°F
Trouble switch	Left end of trainer	Down position
Air source switch	Air conditioning panel	OFF

RECHECK ALL SWITCH POSITIONS

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SWITCH	OPERATING COMPONENT	RESULT OR POSITION
Ground air source switch ON		
DEPRESS the left engine start switch momentarily	Pressure regulating valve	Closed
	Hot air temp control valve	Closed
DEPRESS the left engine starter overspeed cutout switch momentarily	Pressure regulating valve	Open
	Hot air temp control valve	Open
The left engine is running so there is no need for the ground air source. The right engine will be started with bleed air from the left engine.		
Ground air source switch OFF		
DEPRESS right engine starter switch momentarily	Pressure regulating valve	Closed
	Hot air temp control valve	Closed
DEPRESS right engine starter switch momentarily	Pressure regulator valve	Open
	Hot air temp control valve	Open
Air source selector to BOTH	Left and right bleed air check and shutoff valves	Open

Note: With both engines running and the air source switch in the both position there is air for the windshield clearing system. On the windshield clearing system panel there are two switches; RAIN REMOVAL SWITCH and the WINDSHIELD SELECTOR SWITCH. The rain removal switch has three positions, RAIN REMOVAL, WASH AND OFF. The windshield selector switch has three positions, L (LEFT), BOTH AND R (RIGHT).

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SWITCH POSITION	OPERATING COMPONENT	RESULT OR POSITION
Windshield selector switch to BOTH		
Rain removal switch to the RAIN REMOVAL position	Left rain removal SOV	Open
	Right rain removal SOV	Simulated Open
	Ejector valve	Open
Windshield selector switch to LEFT		
	Left rain removal SOV	Open
	Right rain removal SOV	Closed
	Ejector valve	Open
Windshield selector switch to RIGHT		
	Right rain removal SOV	Simulated Open
	Left rain removal SOV	Closed
	Ejector valve	Open
Windshield selector switch to BOTH		
Rain removal switch WASH momentarily	Left windshield wash SOV	Open 5 sec
	Left rain removal SOV	Open 5 sec
	Right windshield wash SOV	Simulated Open 5 sec
	Right rain removal SOV	Simulated Open 5 sec
	Ejector valve	Open 5 sec
Windshield selector switch to LEFT		
Rain removal switch to WASH momentarily	Left windshield wash SOV	Open 5 sec
	Left rain removal SOV	Open 5 sec
	Ejector valve	Open 5 sec
Windshield selector switch to RIGHT		
Rain removal switch to WASH momentarily	Right windshield wash SOV	Simulated Open 5 sec
	Right rain removal SOV	Simulated Open 5 sec
	Ejector valve	Open 5 sec

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SWITCH POSITION	OPERATING COMPONENT	RESULT OR POSITION
Windshield selector switch to BOTH		
Rain removal switch to RAIN REMOVAL	Left rain removal SOV Right rain removal SOV Ejector valve	Open Simulated Open Open
Note: The windshield overhear sensor protects the windshield by shutting off BOTH rain removal SOVs during the overhear condition. It also lights the <u>windshield hot light</u> on the caution panel. The windshield wash system is <u>partially</u> inoperative because there isn't any rain removal. We can simulate a windshield overhear condition on the simulation panel.		
Windshield overhear simulation switch to > 445°F	Right rain removal SOV Left rain removal SOV Windshield hot light	Closed Closed ON
Rain removal switch to WASH momentarily	Right windshield wash SOV Left windshield wash SOV Ejector valve Right and left rain removal SOV	Open 5 sec Simulated Open 5 sec Open 5 sec Closed because of windshield overhear condition
Windshield overhear switch to < 445°F	Windshield hot light	OFF

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SECTION III
TROUBLESHOOTING (TRAINER)

1. For this part of the project you will be given three malfunctions to troubleshoot in lab 109. After you have completed these, you will be instructed to go to lab 106 where you will be given two additional malfunctions to troubleshoot. Of the five troubles given, you must locate four of them correctly. Tell the instructor you are now ready to troubleshoot. He will give you an AFTO Form 781A which lists three malfunctions. Put a trouble switch to the ON position and troubleshoot until you find the malfunction. Complete the 781A by listing the corrective action and making all other entries as required.

SECTION IV
TROUBLESHOOTING (CAPSULE)

1. Report to lab 106. Tell the instructor you are ready to troubleshoot the F-111 capsule windshield clearing system.

STEP 1

Below is a list of controls and parts of the system. You can visually check these from outside the capsule. As each part is found, put a checkmark in the blank space.

- ____ 1. Temperature control panel. Look on the center console between the seats.
- ____ 2. Windshield clearing and anti-icing panel. Look on the bottom of the left front panel.
- ____ 3. Ejector valve light. Look on the upper right corner of the front panel.

STEP 2

It's now time to prepare the capsule for an operational check. Follow the checklist below. Be sure to read each step carefully. As each step is completed, put a checkmark in the blank space.

- ____ 1. Locate the two electrical cords on the F-111 capsule. Plug these cords into the wall outlets.
- ____ 2. Locate the "F-111" switch on the bleed air shutoff valve control panel. Place this switch to the closed position.
- ____ 3. Locate the F-111 power switch on the front of the trainer. Place this switch to the ON position.

Note: To perform an operational check on the windshield clearing system we need a source of hot pressurized air. For this test we will use a MA-1A ground air cart.

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4. Go to room 108. Take a headset off the rack on the left side of the room.

SAFETY STEP: Due to excessive noise, ear protectors must be worn while operating the MA-1A.

5. Locate the bleed air shutoff valve switch above the window. Place this switch to the closed position.
6. Go outside and prepare the MA-1A for starting.
- a. Check for fuel.
 - b. Remove the protective covering.
 - c. Check for oil.
 - d. Unwrap the ground hose and lay it out flat along the ground (pointed away from the control panel).
 - e. Connect the battery.
 - f. Open the vents. Make sure the limit switch on the front vent is in place.
 - g. Open the control panel.
 - h. Check the maintenance forms.
7. You are now ready to "blow out the hose." This is done to insure no foreign matter is in the hose. Place your headset over your ears at this time.
- a. Place the master run switch to the RUN position.
 - b. Place the start switch to the ON position for about 10 seconds, then let go.
 - c. Place the output air switch to the ON position when the output air light comes on.
8. After about 30 seconds, place the output air switch to the OFF position.
9. Now connect the hose to the receptacle on the wall.
10. Once the hose is secured, step away from the hose and place the output air switch back to the ON position.
11. Go back to room 108 and place the bleed air shutoff valve switch to the OPEN position. Also, place your headset back on the rack.

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- ___ 12. Return to room 106 and place the F-111 switch to the open position.
- ___ 13. Remove one headset per person from the gray locker.
- ___ 14. You are now ready to begin the operational check. To perform this check, use table 1 below. You will have to get in the capsule to perform the operational check.

Note: For the following steps in the windshield clearing system operational check, DO NOT OPERATE the windshield clearing system longer than 30 seconds. Allow a 30-second cooling period between operations.

STEP	CONTROL	POSITION	RESULT
1	Windshield Clearing Switch	Rain Removal	Airflow should be felt over both windshields, overheat should be off, ejector light should be on.
2	Windshield Selector Switch	Move to left, right, then to both	Airflow should be felt over appropriate windshield. Overheat light should be off, ejector light should be on.
3	Windshield Clearing Switch	Off	Airflow across both windshields should cease.

Table 1. Operational Check.

STEP 3

Now that you have performed the operational check, you should be familiar with the normal operation of the system. The instructor will now put two malfunctions in the system. After each malfunction is turned on, you must go through the operational check until you locate the malfunctions.

STEP 4 - Shutdown Procedures

- ___ 1. Place the "F-111 Switch" to the CLOSED position.
- ___ 2. Place the F-111 power switch to the OFF position.
- ___ 3. Unplug and stow your headsets.

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- ___4. Go to room 108 and place the bleed air shutoff valve switch to the CLOSED position.
- ___5. Remove a headset from the rack and place over your ears.
- ___6. Go outside to the control panel on the MA-1A.
- ___7. Place the output air switch to the OFF position.
- ___8. When the output air gage reaches zero, place the master run switch to the OFF position.
- ___9. After the turbine stops spinning, close the vents.

SAFETY STEP: The outlet vent may still be hot. Be careful when closing this vent.

- ___10. Unplug the battery.
- ___11. Place the hose back in the original position.
- ___12. Place the protective covering back over the MA-1A.
- ___13. Go back to room 108 and return your headset to the rack.
- ___14. Return to room 106 and wrap all electrical cords around the hook, located in front of the capsule.
- ___15. You are now ready to fill out your data collection forms, using the information in section V.

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Technical Training

Aircraft Environmental Systems Mechanic

AIR CONTROL VALVES

5 September 1974



CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR42231-PT-405, 20 January 1972.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TIOC - 2

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42231 instructional system. The material contained herein has been validated using thirty 42010 students enrolled in the 3ABR42231 course. 93% of the students taking this text surpassed the criterion called for in the approved lesson objectives. The average student required 40 minutes to complete the text.

OBJECTIVES

After completion of the text, you will be able to:

1. State the three main categories of air control valves.
2. Explain the principles of air check valves.
3. Explain the principles of pneumatic actuated valves.
4. Explain the principles of electric actuated valves.
5. State the power requirements for electric motor actuated valves.
6. State the power requirements for pneumatic actuated valves.

Standard of Performance:

You will demonstrate an acceptable attainment of the objectives if you can answer 70% of the multiple-choice questions correctly.

INSTRUCTIONS

Note: Before proceeding, remove the response sheets at the back of this text. Then enter your answers on the removed sheets.

This programmed text presents information in small steps called "frames." After reading each frame, you are expected to respond by choosing either TRUE or FALSE. DO NOT MARK IN THIS TEXT.

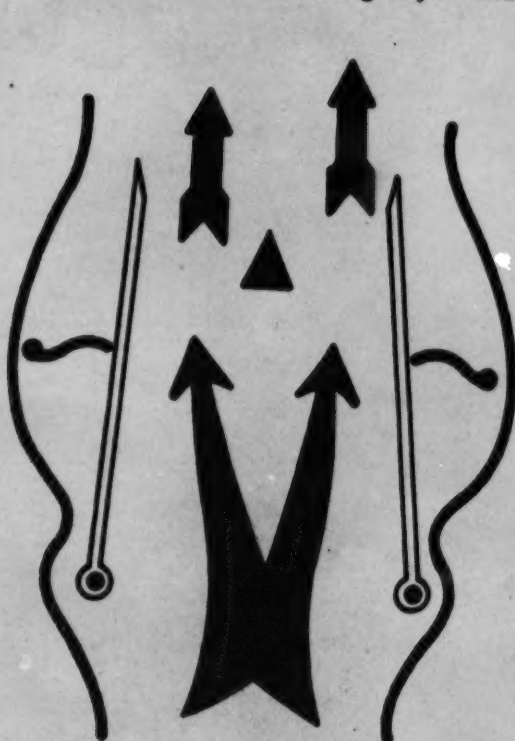
Read the material presented, select your response to the question, and indicate your response on the response sheets. After you respond to the question, compare your answer with the one given on the top of the even numbered or available page. If you are correct, go on to the next frame. If your answer is wrong, read the frame again.

Frame 1

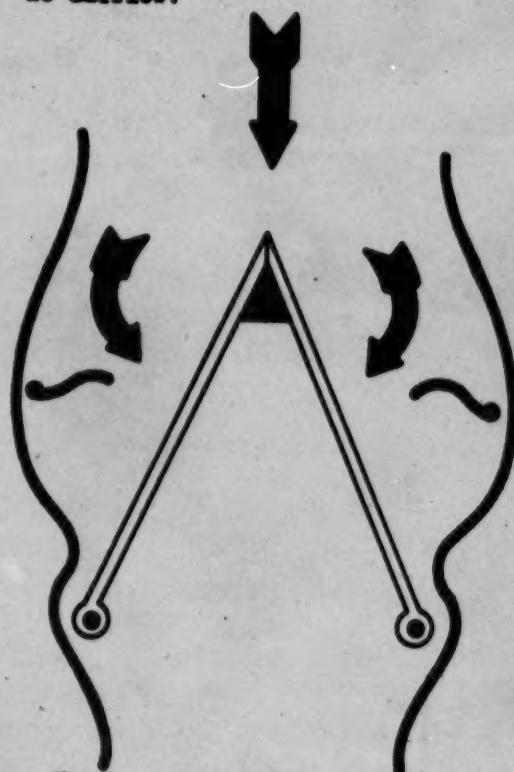
The three main types of air control valves that are discussed in this text are air check valves, electric motor operated valves, and pneumatic actuated valves.

Let's first look at the air check valves. They vary in size from about one inch in diameter (used in small air lines) to 5 inches in diameter used in air supply lines. However, no matter how large or small the check valves are, they all are used for the same purpose. They prevent the reverse flow of air. In other words, they allow air to flow in one direction only. There is an arrow (+) on the valve housing to show you which direction to install the valve. Always install the valve with the arrow pointing in the direction of airflow.

You can see what would happen if the check valve was installed in the system the wrong way. That's right--no airflow.



Check Valve - Normal Airflow.



Check Valve - Reverse Airflow.

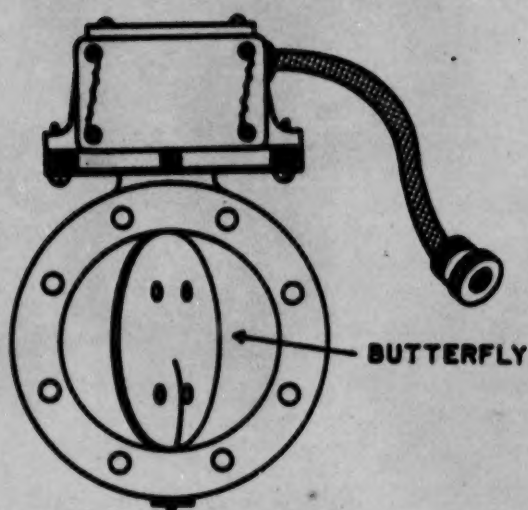
Note: Determine which of the following statement(s) are true and which are false.

1. The purpose of the check valve is to prevent reverse flow of air.
2. Always install the valve with the arrow in the direction of airflow.
3. It doesn't matter which way a check valve is installed in the system.
4. No matter how large a check valve is, it has the same purpose as a small one?

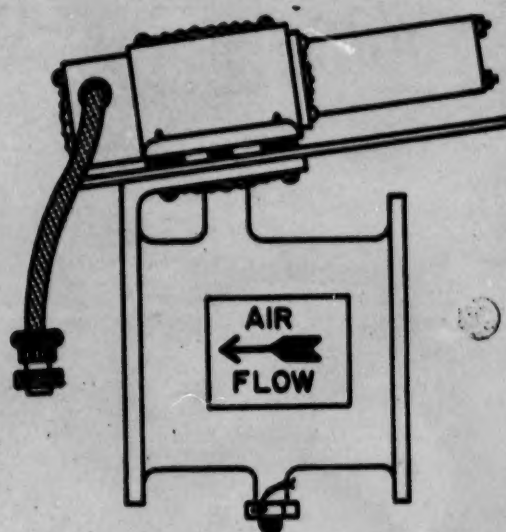
CORRECT RESPONSES TO FRAME 1: 1. T 2. T 3. F 4. T.

Frame 2

We will now look at electric motor actuated valves. These valves are of different types and are used for different systems. Some different types of electric motor actuated valves are the butterfly, spoon and sliding gate. All these valves are driven by an electric motor. As environmental systems repairmen we are mainly concerned with the butterfly type valve. The butterfly valves can start and stop airflow, such as a shutoff valve. They are also used to slow airflow, such as a modulating valve. Modulating valves can be stopped anywhere between full open or full closed.



Internal View, Butterfly Valve Open



External View of Valve.

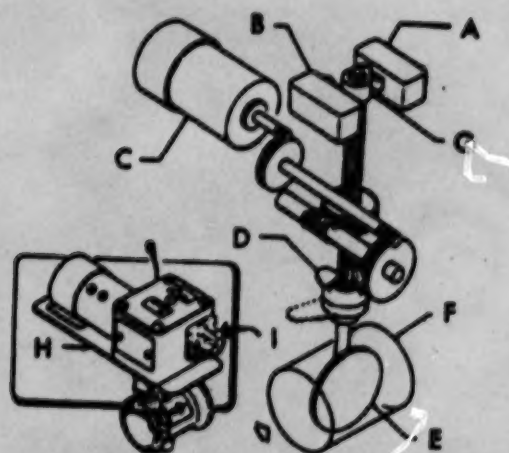
Electric Motor Actuated Valve.

Note: Determine which of the following statement(s) are true and which are false.

1. Electric motor actuated valves cannot be stopped between full open and full closed.
2. Shutoff valves are used to start and stop airflow.
3. Electric motor actuators can operate various types of valves.
4. Modulating valves can be stopped anywhere between full open and full closed position.

Frame 3

Let's take a look at the power requirements of some of the electric motor actuated valves. The electrical power used by most of the valves is either 28 volts DC; 115 volts AC, 400 Hertz, single phase; or 230 volts AC, 400 Hertz, three phase. You can see there are valves with various voltages. One way you can find out what electrical power a valve needs is to look on the data plate attached to the valve. If the information is not on the data plate look in the technical order for the valve. The parts of a typical valve are identified in the illustration.



- | | |
|-------------------------|------------------|
| A. OPEN LIMIT SWITCH | F. VALVE HOUSING |
| B. CLOSE LIMIT SWITCH | G. ACTUATING CAM |
| C. MOTOR | H. HEAT SHIELD |
| D. POSITION INDICATOR | I. AM CONNECTOR |
| E. BUTTERFLY VALVE OPEN | |

Electric Motor Actuated Butterfly Valve.

Note: Determine which of the following statement(s) are true and which are false.

1. There are several voltages that can be used for power in electric motor actuated valves.
2. There is only one limit switch in each motor actuator.
3. Another name for a motor is an actuator.
4. Power requirements for valves can be found in technical orders.

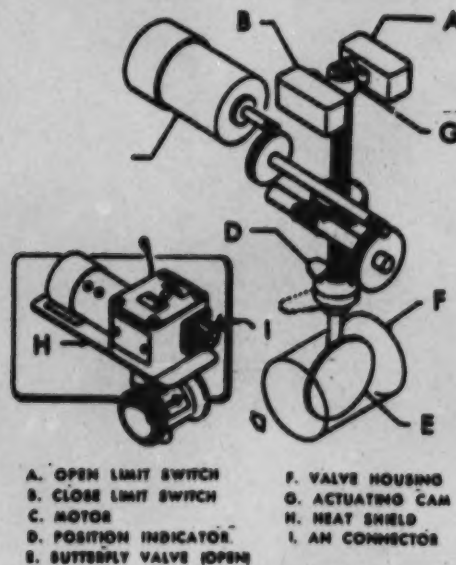
CORRECT RESPONSES TO FRAME 2: 1. F 2. T 3. T 4. T.

CORRECT RESPONSES TO FRAME 3: 1. T 2. F 3. T 4. T.

Frame 4

Let's go into the function of the parts of an electric motor actuated valve. Follow the diagram below as you go along.

The motor (c) is used to drive the gear train. The gear train drives the actuating cam (g) and position indicator (d). The actuating cam contacts the limit switches. Limit switch (a) stops the motor when the butterfly valve (e) is in the full open position. Limit switch (b) stops the motor when the butterfly valve is in the full closed position. The gear train is used to increase torque of the motor. The position indicator is used to save you time as a mechanic. It tells you at a glance what position the butterfly valve is in, without having to remove it from the aircraft.

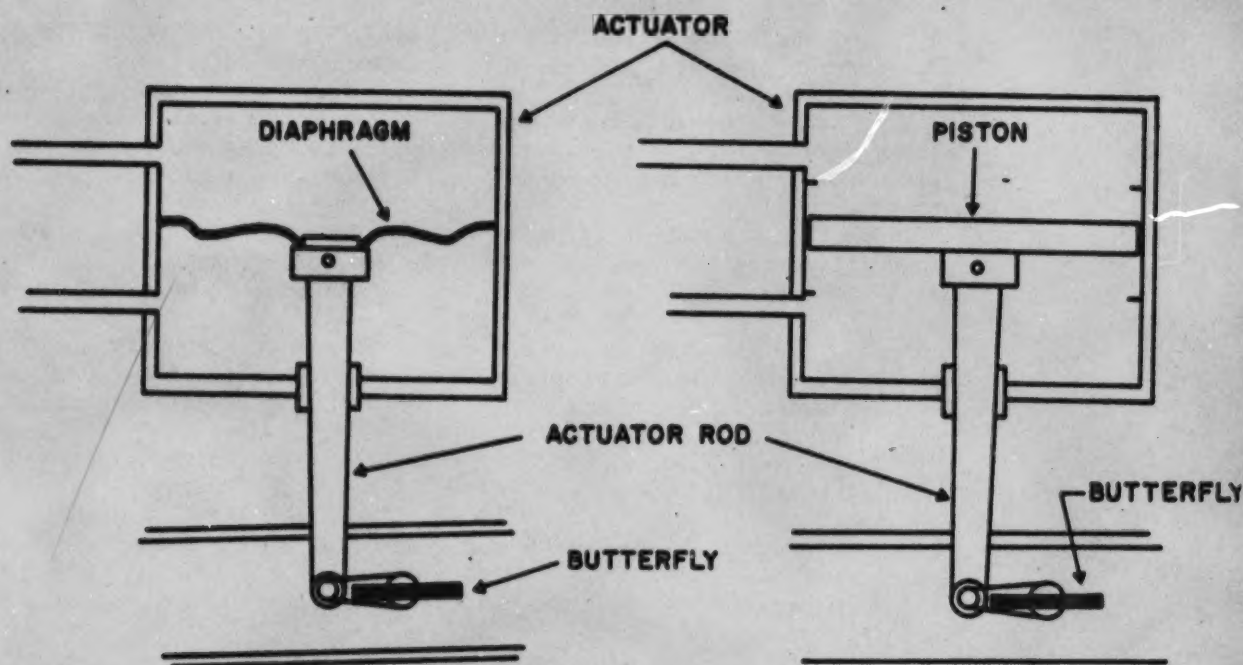


Electric Motor Actuated Valve.

Note: Determine which of the following statement(s) are true and which are false.

1. The motor drives the gear train, actuating cam, and position indicator.
2. Both limit switches are contacted at the same time.
3. The gear train increases the torque of the motor.
4. The mechanic can tell what position the butterfly valve is in by looking at the position indicator.

Pneumatic actuated valves are actuated by air. There are two main types of pneumatic actuated valves; piston or diaphragm operated. These valves are used in the bleed air system to control airflow. The two major components are the actuator and the butterfly. A fail-safe system is built into the valve. Fail-safe means the valve would return to the original position (open or closed), if electrical power or system pressure failed. Next we will discuss valve controlling devices.



Diaphragm Actuated Valve

Piston Actuated Valve

Note: Determine which of the following statement(s) are true and which are false.

1. Pneumatic actuated means air actuated.
2. All valves are fail-safe closed.
3. Piston type valves are electrically operated.

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CORRECT RESPONSES TO FRAME 4: 1. T 2. F 3. T 4. T.

CORRECT RESPONSES TO FRAME 5: 1. T 2. F 3. F.

Frame 6

Controlling devices for pneumatic valves consist of: (1) solenoids, (2) thermostats, (3) pneumatic relays, or (4) pressure switches which control the position of the valve.

1. The solenoid controls air pressure to open or close a valve by allowing air pressure to stop or pass through the solenoid.

2. The pneumatic thermostats are controlled by temperature which either open or close a small bleed port, controlling the buildup or release of pressure acting on the diaphragm of a pneumatic valve.

3. The pneumatic relays are used in the pressurization system to prevent lag time between the controller and outflow valves, when the outflow valves are located a considerable distance between units.

4. The pressure switches are used in conjunction with a valve that operates under a pregiven pressure similar to an aneroid switch. Most pressure switches operate in conjunction with a pneumatic thermostat.

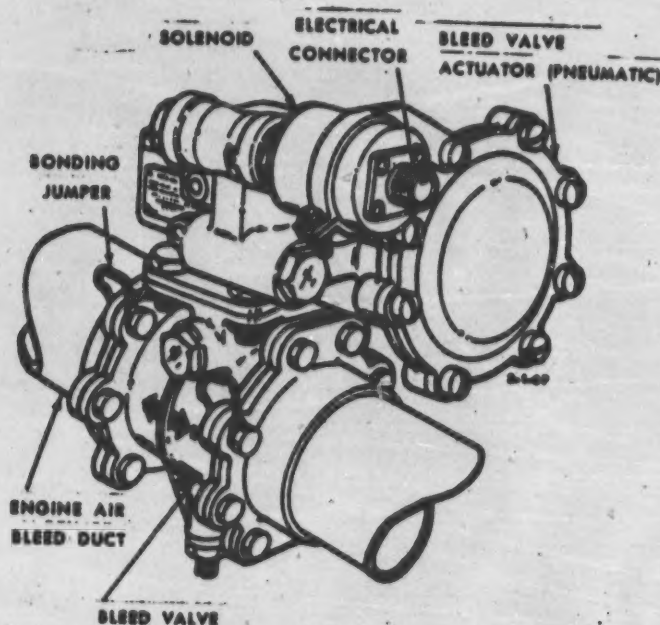
Note: Determine which of the following statement(s) are true and which are false.

1. Pneumatic thermostats are controlled by air pressure.
2. Lag time between the controller and outflow valves is controlled through a pneumatic relay.
3. All pressure switches work in conjunction with a pneumatic thermostat.
4. A solenoid is a controlling device.

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Types of Pneumatic Valves. The piston-actuated valve has a piston similar to the one in a car. Instead of steel rings, rubber "O" ring seals are used. The piston rod is connected to a mechanical linkage.

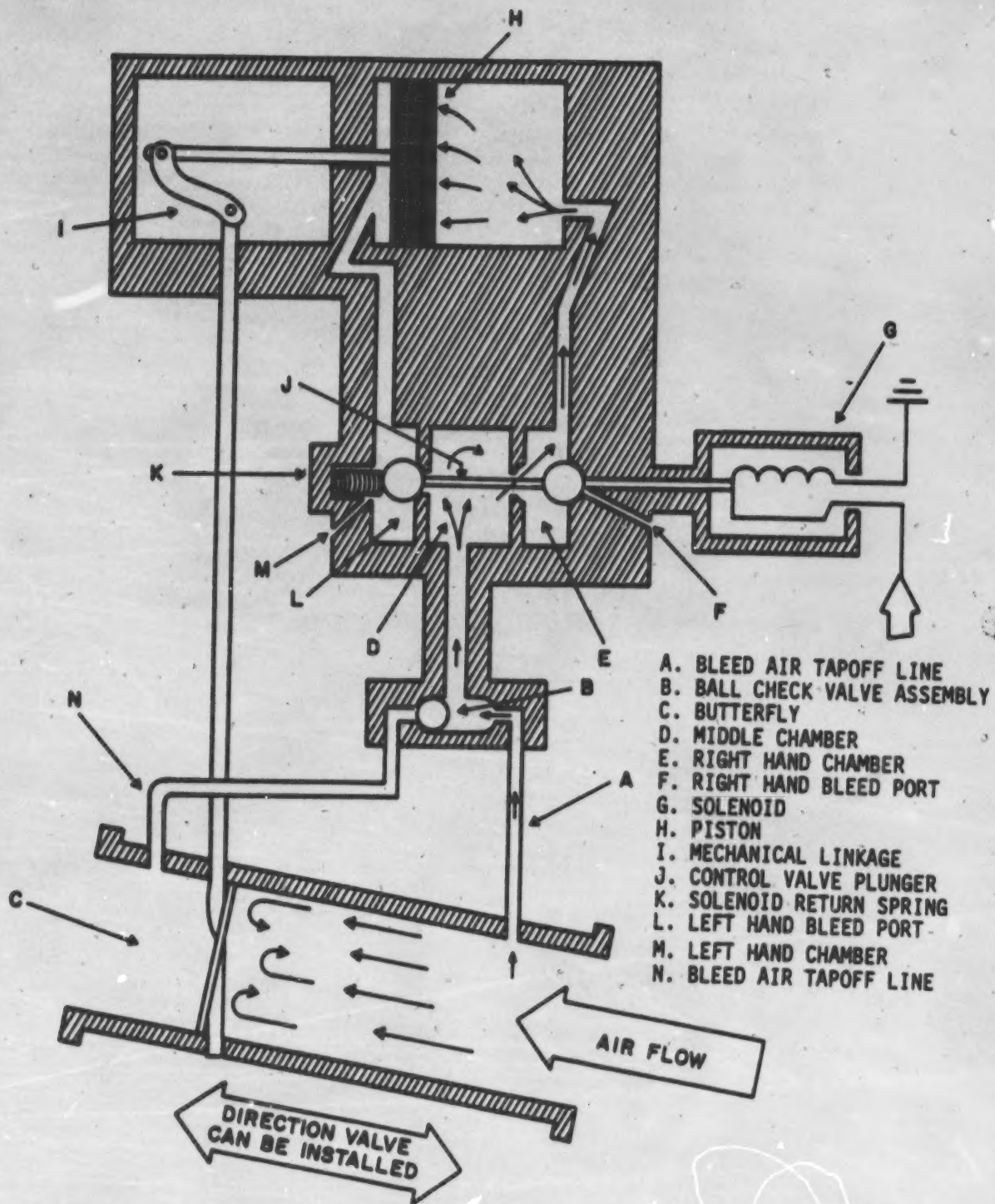
The linkage is attached to the butterfly valve. When air pressure is applied to the top or bottom of the piston, the valve will open or close. Normal opening or closing time is approximately one second for all valves. A piston actuator is normally controlled by a solenoid valve. A solenoid valve is sometimes referred to as a switcher valve. It switches the air pressure either to the top or bottom of the piston. This controls the direction of piston movement.



Pneumatic Piston Actuated Valve.

Note: Determine which of the following statement(s) are true and which are false.

1. "O" ring seals are used on piston-actuated valves.
2. Normally 1 second is required for the valve to open.
3. A switcher valve controls the mechanical linkage.



Pneumatic Piston Actuated Valve (De-energized Closed).

CORRECT RESPONSES TO FRAME 6: 1. F 2. T 3. F 4. T.

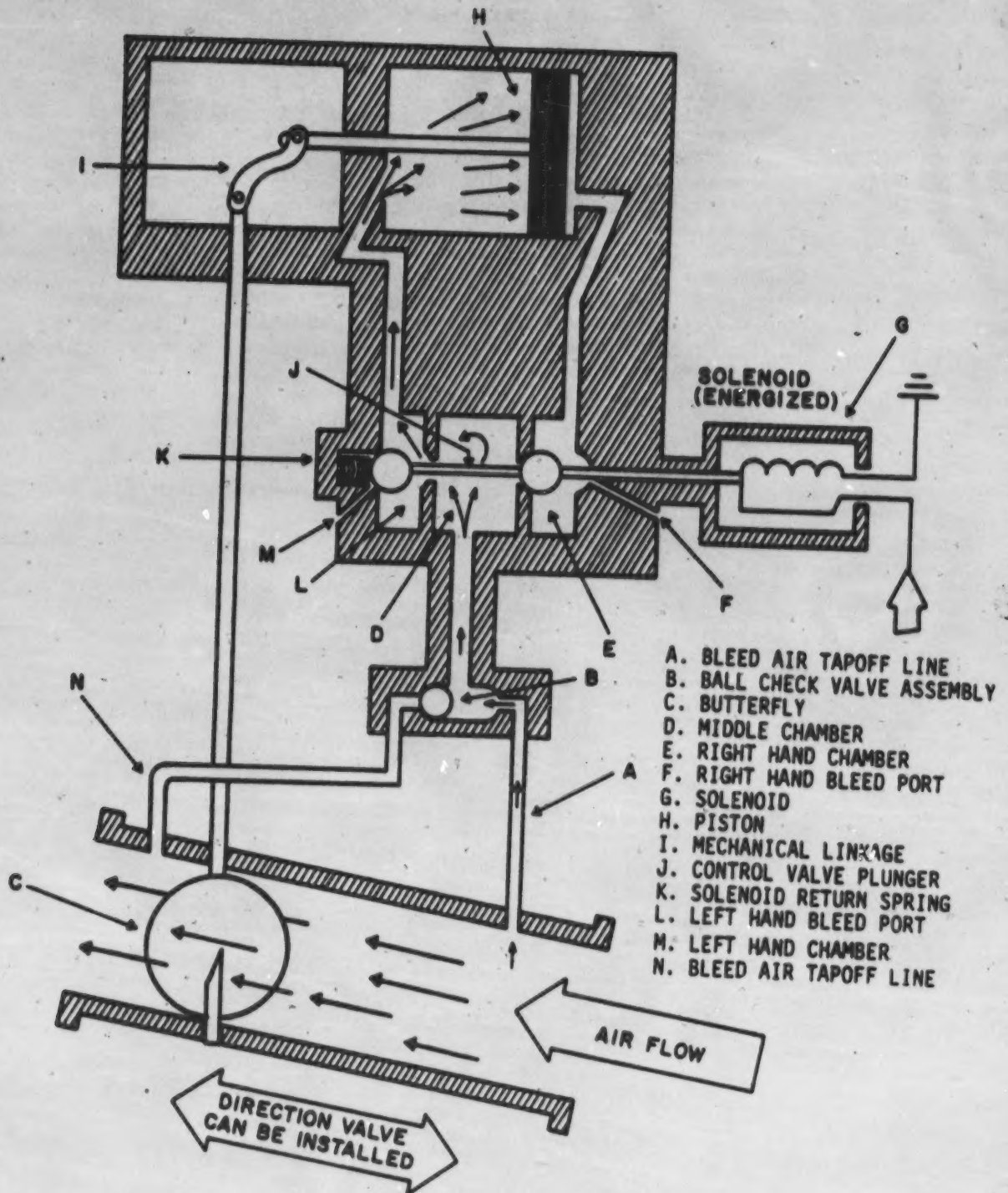
CORRECT RESPONSES TO FRAME 7: 1. T 2. T 3. T.

Frame 8

Operation of the Pneumatic Piston Actuated Valve. Refer to the illustration of the valve on page 8. Air pressure is tapped from the body of the valve through (a or n) either side of the butterfly (c). Airflow is then routed to the shuttle valve (b). The shuttle valve prevents air pressure from escaping to the opposite side of the butterfly. The shuttle valve directs air pressure to the middle chamber (d). At this point the air will be controlled by the solenoid (g). The direction of the air movement will depend on the position of the solenoid. When the solenoid is de-energized air will pass into the right hand chamber (e). From the right chamber air flows up the passageway to the top of the piston (h). Air pressure forces the piston to the left. Through mechanical linkage, the butterfly (c) will be held closed.

Note: Determine which of the following statement(s) are true and which are false.

1. Air is trapped from either side of the butterfly.
2. The direction of airflow depends on the check valve position.
3. A de-energized solenoid will cause the valve to close.



Pneumatic Piston Actuated Valve (Energized Open).

CORRECT RESPONSES TO FRAME 8: 1. T 2. F 3. T.

Frame 9

Refer to the illustration on page 10. To open the valve, 28 volt DC is applied to the solenoid valve (g), energizing the solenoid. This action causes the control valve plunger (j) to move to the left. The plunger closes the air inlet port of the right hand chamber (d). The right hand bleed port (f) is now opened. Air from the top of the piston is vented overboard. With the solenoid energized, the left hand bleed port (l) is closed. The left hand chamber (a) inlet port is open. This allows pressure to be applied to the bottom of the piston. The piston (h) will be forced to the right moving the mechanical linkage and opening the valve. Air can then flow through the valve (o). To close the valve, de-energize the solenoid (g). The solenoid return spring (k) will move the control valve plunger to the right. Air pressure is directed to the top of the piston, closing the valve. Air is vented from the bottom of the piston through the left hand bleed port (l). Port leakage past the butterfly is compensated by adjusting the mechanical linkage of the valve.

Note: Determine which of the following statement(s) are true and which are false.

1. Air directed to the bottom of the piston will open the valve.
2. Bleed ports are used to bleed the air from the top and bottom of the piston.
3. The solenoid is energized to open the butterfly.

CORRECT RESPONSES TO FRAME 9: 1. F 2. T 3. T.

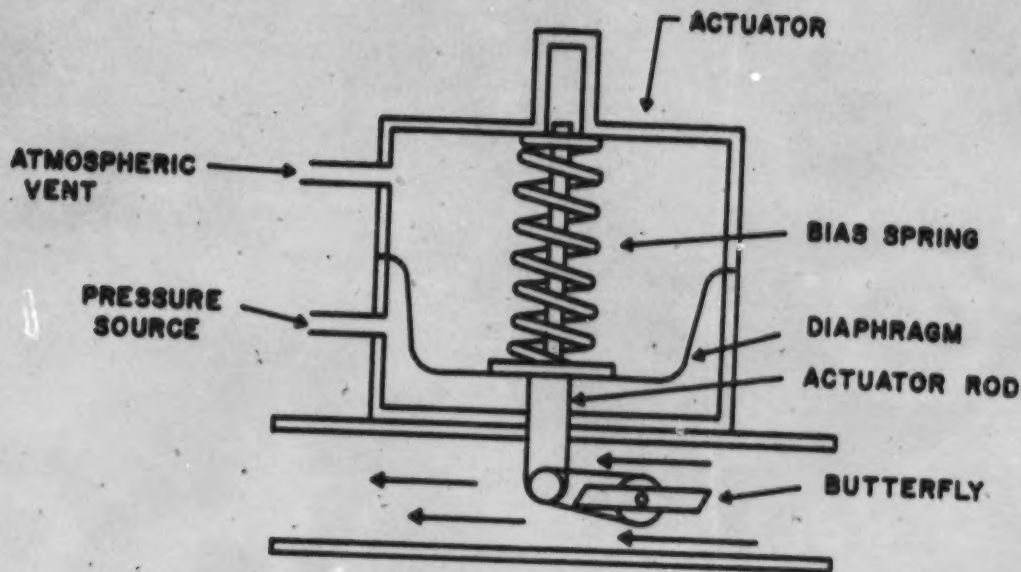
Frame 10

Diaphragm Actuated Valves. A diaphragm actuated valve is similar to a piston actuator with the exception of a piston; a diaphragm is used instead. A diaphragm is a canvas cloth impregnated and coated with rubber. This prevents air from passing through it. However it is flexible enough to allow movement. The diaphragm separates two chambers. One chamber is normally vented to the atmosphere. The other has a spring to load the butterfly valve to the open or closed position. Some valves have the spring on the pressure side, but these are exceptions to the rule. The other chamber of the actuator is connected to a pressure source. Attached to the diaphragm is a rod. The rod is connected to the mechanical linkage of the butterfly shaft.

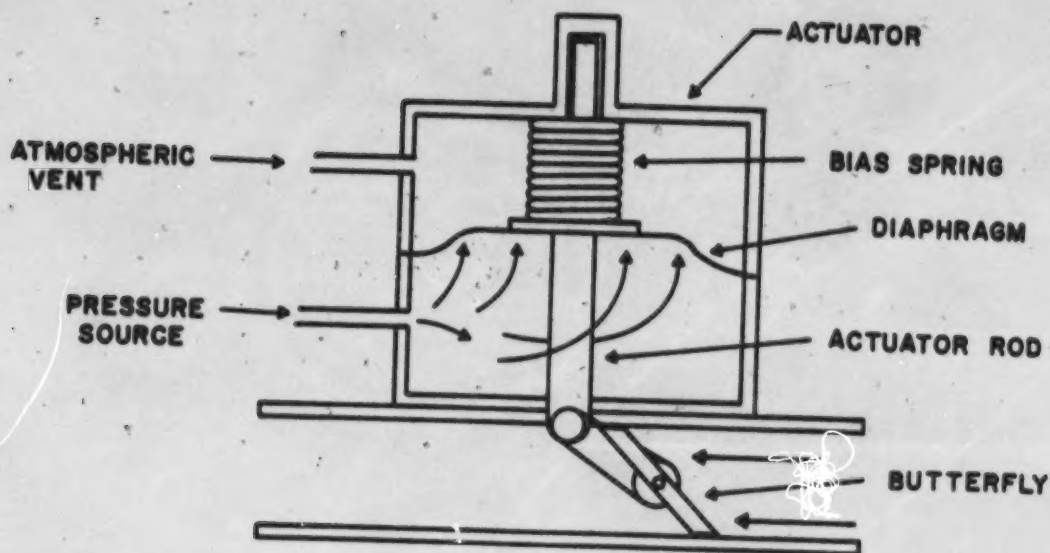
Note: Determine which of the following statement(s) are true and which are false.

1. A diaphragm is very flexible.
2. The diaphragm actuator rod is connected to a mechanical linkage.
3. The valve could be spring loaded to the open and closed position.

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Diaphragm Actuated Valve (Spring Loaded Open).



Diaphragm Actuated Valve (Spring Loaded Open)
With Air Pressure Applied to Close the Valve.

CORRECT RESPONSES TO FRAME 10: 1. T 2. T 3. F

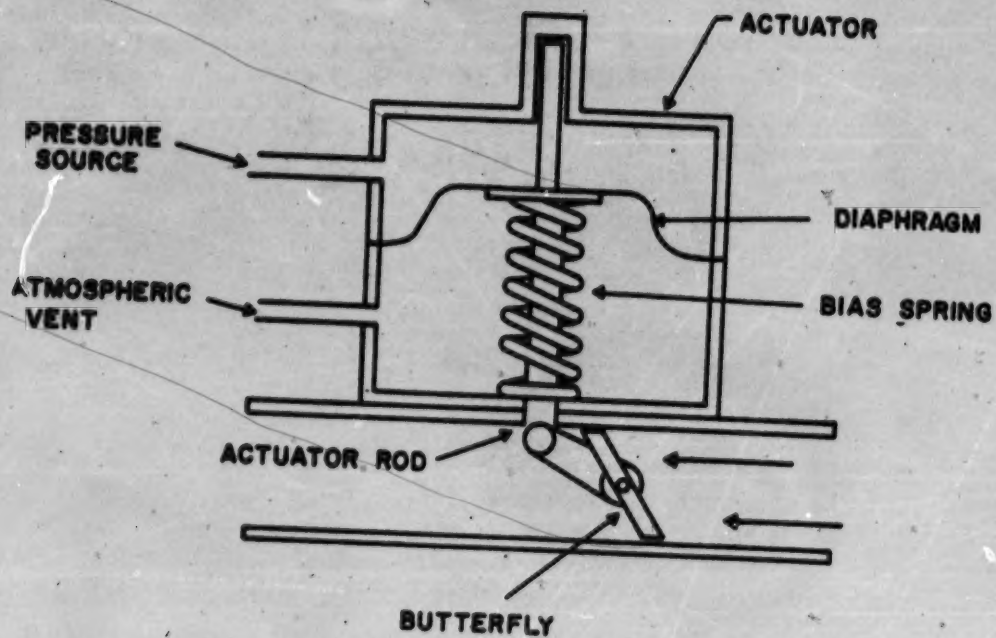
Frame 11

Spring Loaded Open Diaphragm Actuated Valve. Refer to the top illustration on page 14. This illustration represents a valve, spring loaded to the open position. Let's see how the valve can be controlled. With no pressure at the pressure source, the spring forces the diaphragm down. This forces the actuator rod, through mechanical linkage, to hold the butterfly open. To close the valve (bottom illustration) a pre-determined pressure is applied from the pressure source. Pressure buildup will force the diaphragm upward; compressing the spring. As the diaphragm moves upward, the actuator rod, through mechanical linkage, begins to close the valve. The atmospheric pressure on top of the diaphragm is forced out the atmospheric vent. This allows free movement of the diaphragm.

Note: Determine which of the following statement(s) are true and which are false.

1. To allow free movement of the valve, one side is vented.
2. The valve on page 14 is spring-loaded closed.
3. Atmospheric air pressure is applied to actuate the valve.

2375



Diaphragm Actuated Valve (Spring Loaded).

543

CORRECT RESPONSES TO FRAME 11: 1. T 2. F 3. F.

Frame 12

Spring Loaded Closed Diaphragm Actuated Valve. Refer to illustration on page 16. The spring will push the diaphragm up, causing the actuator rod to hold the butterfly closed. When pressure is applied from the pressure source, the diaphragm will be forced down. The actuator rod moves the butterfly open.

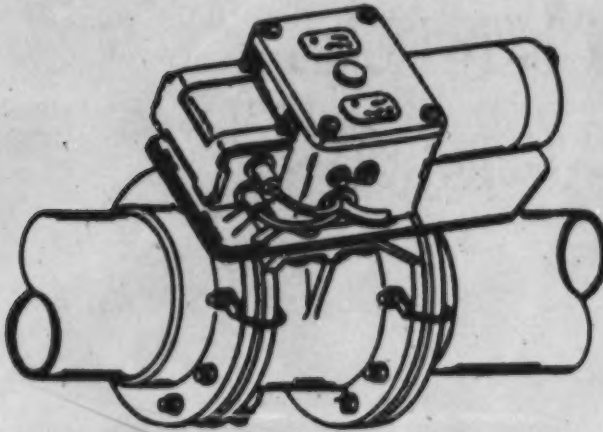
Note: Determine which of the following statement(s) are true and which are false.

1. With the valve spring loaded to the closed position, pressure is applied to open the valve.
2. Pressure is applied to the bottom of the valve diaphragm to open the valve.

CORRECT RESPONSES TO FRAME 12: 1. T 2. T

Frame 13

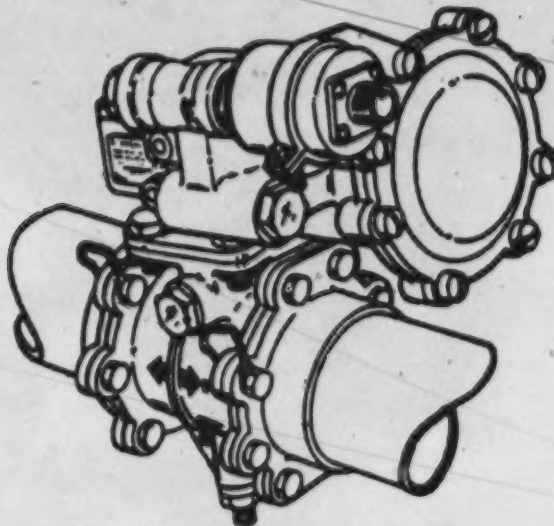
Air check valves are always installed in a system with the arrow pointing in the direction of airflow. Remember the purpose and power requirements for each type of valve discussed in the text. If in doubt, recheck the text to make sure. Now here is another look at the valves we have discussed. Remember what they look like. You will see them again.



Electric Motor Actuated Butterfly Valve



Air Check Valve



Pneumatic Piston Actuated Valve

No Response Required

Frame 14

Bench testing of an air control valve can be a simple matter of just operating the valve. An operational check (not a bench check) can be performed on the aircraft. This check will allow you to determine if the valve is faulty; or the pneumatic system has failed. When a valve is not operating properly, it must be removed and sent to your shop for repairs. Not all valves are reparable at base level. Some valves must be sent to depot for repair. However, if you are authorized to repair a valve, your shop will have the equipment and TOs available. The TOs will explain how to inspect, bench test and repair the valve. Some valves may also require a special check. These checks are outlined in the Time Compliance Technical Orders (TCTO). If a valve has been in storage for an extended period of time, then all the rubber parts must be replaced. Such as; O-ring seals, gaskets and diaphragms. TO 00-20K-6 series outlines the maximum time these valves can be stored. Cure date kits (C kits) are used to repair these valves. Cure date kits include all the rubber parts needed to repair any given valve. The cure date kit has a life time storage of 3 years. After a C kit has been stored for 3 years it can no longer be used. Always check the C kit shelf date prior to using the kit. All the parts included in the C kit should be used when repairs are made to a valve.

NO RESPONSE REQUIRED

THE END.

FRAME 1

1. _____

2. _____

3. _____

4. _____

FRAME 2

1. _____

2. _____

3. _____

4. _____

FRAME 3

1. _____

2. _____

3. _____

4. _____

FRAME 4

1. _____

2. _____

3. _____

4. _____

FRAME 5

1. _____

2. _____

3. _____

FRAME 6

1. _____

2. _____

3. _____

4. _____

FRAME 7

1. _____

2. _____

3. _____

FRAME 8

1. _____

2. _____

3. _____

FRAME 9

1. _____

2. _____

3. _____

FRAME 10

1. _____

2. _____

3. _____

FRAME 11

1. _____

2. _____

3. _____

FRAME 12

1. _____

2. _____

FRAME 13No Response
RequiredFRAME 14No Response
Required

2380

REPAIR THE MAN



PROGRAMMED TEXT

3ABR42331-PT-312A

Technical Training

Aircraft Environmental System Mechanic

PRINCIPLES OF AIRFLOW CONTROL AND SHUTOFF VALVE

20 November 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

76-30856

FOREWORD

This programmed text is prepared for and was validated with students in the 3ABR42231 Instructional System. The average time required to complete this text was 92 minutes.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Identify the major components of the Airflow Control and Shutoff Valve.
2. Explain the operation of the Airflow Control and Shutoff Valve.-

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Read the material presented in each frame and respond as directed. After each frame you are required to answer true/false statements, multiple choice questions, match statements, or identify a part on a drawing. DO NOT MARK IN THIS TEXT. After making your response, check the accuracy at the top of the following page. If your answer is not correct, go over the material until you understand the reason for your error before going to the next frame.

INTRODUCTION

This text was prepared to help you to learn to maintain the Airflow Control and Shutoff Valve. You will learn to identify and explain the function of each of its parts, and how to make the necessary checks and adjustments. A numbered schematic is on the last page at the back of the text, to help you see the relationship of the components. Remove this page to refer to as you read this text. The venturi forms the base of the unit and is a source of differential pressure for operating many of the parts. The servo controller, pressure regulator, solenoid valve "A", pneumatic actuator and butterfly assembly make up the normal control system of the unit. Other parts that increase the efficiency of the unit under various operating conditions are the altitude compensator, solenoid valve "B", and manual override control.

Supersedes 3ABR42231-PT-407, 26 May 1971, which may be used until existing stocks are exhausted.

OPR: TASTC

DISTRIBUTION: X

TASTC - 150; TTVGC - 2

The venturi, figure 2 on page 17 (12), forms the base for the airflow control and shutoff valve. With no butterfly valve, the venturi is just a flow limiting device; it is not a flow control device. Take a close look at the part with the number 12 near it. Notice that a cross sectional area of the device has been reduced to a size that is somewhat smaller than either of the ends. This is the throat of the venturi. To the right of the throat is the inlet to the venturi, this is the base. At both the throat and the base of the venturi there are tap-off connections through which air pressure is taken. One is at the throat (A) and the other is at the base (B). (Just one tap-off connection is shown on the schematic for the base of the venturi.) When a flow of air is sent through the venturi in the direction shown by the arrow, it gives an effect that is known as Bernoulli's principle. This principle states, "As the speed of air through the throat of the venturi increases, pressure at the throat drops."

Use figure 2 as a guide to pick the statements that are true (T) and those that are false (F).

1. Pressure is higher at point A than it is at point B.
2. The venturi is a flow limiting device.
3. High pressure is taken from the throat of the venturi.
4. The venturi is a source of differential pressure.
5. As the speed of air through the throat of the venturi drops, pressure at the throat will rise.

2383

Answers to Frame 1: 1. F 2. T 3. F 4. T 5. T

Frame 2

The servo controller (13) is made up of two diaphragm control sections (figure 1), the main or primary servo section and the secondary servo section. Each servo section is made up of an air chamber divided by a diaphragm. A metering valve is placed between these diaphragms. A spring in the left side of the secondary servo section moves the metering valve to the right (open) when air pressure in both sides of the main servo section is the same (no airflow through the venturi). The metering valve is moved to the left (closed) when pressure in the left side of the main servo section drops. The servo controller sends air to the pneumatic actuator. Air for operation of the servo controller and pneumatic actuator comes from the venturi.

Use figures 1 and 2 as guides to pick the statements that describe the purpose or characteristics of the servo controller. Answer the statements as true (T) or false (F).

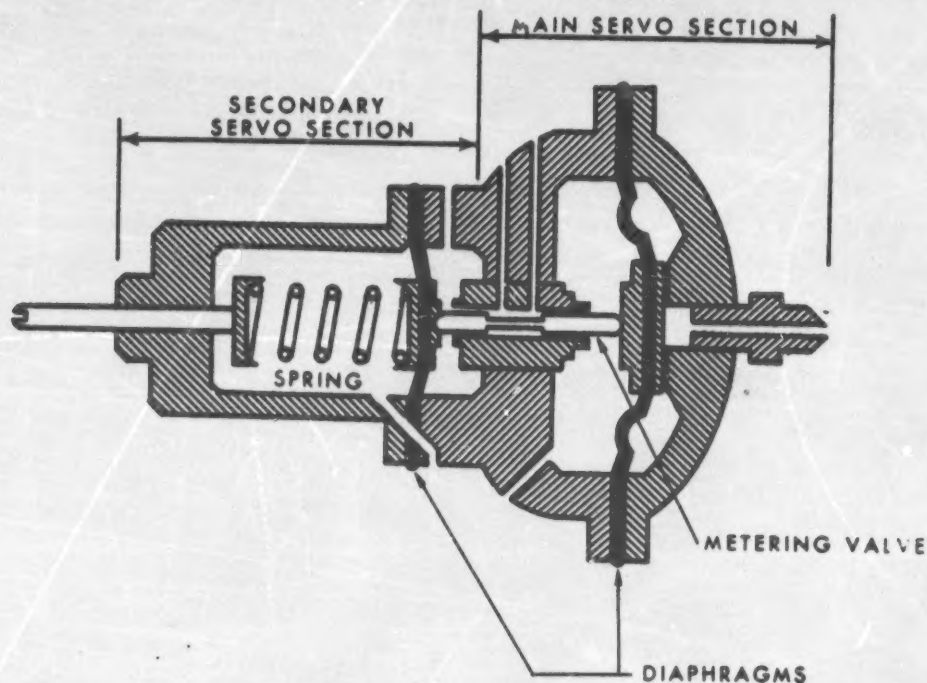
1. The metering valve of the servo controller controls the flow of air to the venturi.
2. The metering valve of the servo controller is set by differential pressure and spring force.
3. The servo controller gets pressure signals from the venturi throat and base.
4. The secondary servo section gets air pressure from the altitude compensator.
5. When the metering valve is moved to the right it partially blocks the outflow air passage.

551

Answers to Frame 2: 1. F 2. T 3. T 4. T 5. F

Frame 3

The metering valve is moved to the right by the spring when there is no pressure in the system, or when pressure from the venturi is the same on both sides of the main servo diaphragm.



The metering valve is moved to the left when pressure at the throat of the venturi drops. The flow of air from the pressure regulator will pass through the servo controller and into the pneumatic actuator. This flow of air is partially blocked by the metering valve.

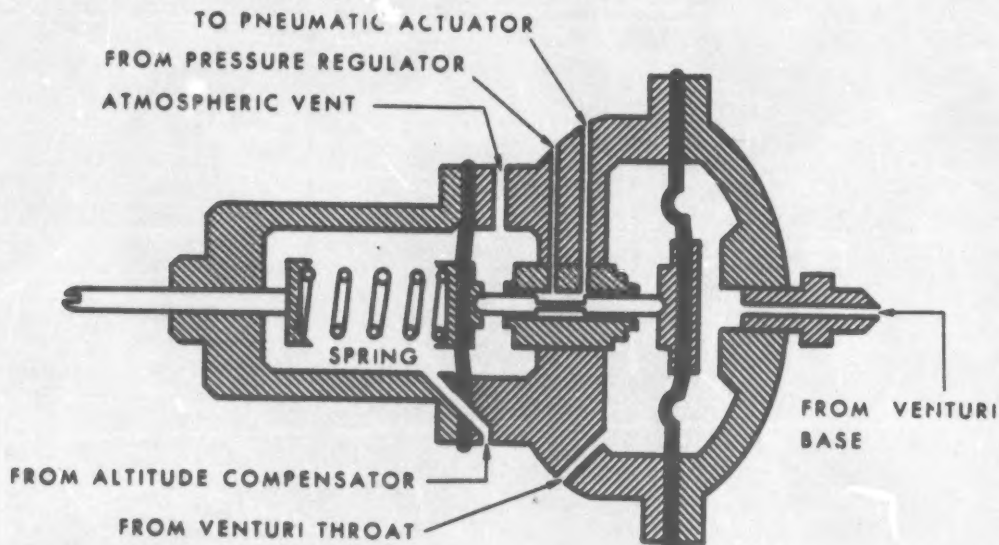


Figure 1. Servo Controller.

2385

Frame 3 (Cont'd)

From the right hand column pick the statement that matches a component or part of a component in the left hand column. Each response may be used only once.

- | | |
|----------------------------|---|
| 1. Metering Valve. | A. Senses differential pressure from the venturi. |
| 2. Secondary Servo Spring. | B. Controls airflow to the Pneumatic Actuator. |
| 3. Main Servo Diaphragm. | C. Moves the metering valve of the Servo Controller to the right. |
| 4. Venturi. | D. Provides differential pressure to the Servo Controller. |
| 5. Servo Controller. | E. Restricts airflow to the Pneumatic Actuator when throat pressure of the venturi drops. |

Frame 4

The pressure regulator (1) keeps a low air pressure in the control system of the airflow control and shutoff valve. Air for this system comes from the base tap-off of the venturi. The pressure regulator is a spring loaded, diaphragm actuated relief valve that keeps air pressure in the control system at a pressure of 12 to 35 psig, this will depend on the supply pressure from the base of the venturi.

From the list of words provided at the bottom of the page, complete each of the statements concerning the venturi, servo controller, and pressure regulator.

1. Pressure for the control system of the airflow control and shutoff valve comes from the _____ tap-off of the Venturi.
2. The venturi sends air pressure to the _____ section of the servo controller.
3. A pressure of 12 to 35 psig is kept in the control system by the _____.
4. Airflow to the pneumatic actuator is controlled by the _____.
5. The pressure regulator is operated by spring force and a pneumatic _____.

Select from the following the word or words to complete the statements.

Pressure Regulator
Base
Diaphragm
Low Pressure

Servo Controller
Throat
Metering Valve
High Pressure

Main Servo
Secondary Servo
Venturi

2387

Answers to Frame 4: 1. Base 2. Main Servo 3. Pressure Regulator
4. Servo Controller 5. Diaphragm

Frame 5

Air pressure from the base tap-off of the venturi goes through the filter (14) where bits of dirt are removed before the air goes in the lower chamber of the pressure regulator. As pressure builds up in the lower chamber, it lifts the diaphragm up against the force of a spring that is pushing down from the top. As the diaphragm goes up, the relief poppet opens and dumps the high pressure from the control systems. The relief poppet is closed by the spring that pushes down from the top.

Use figure 2 as a guide to pick the statements that which are true (T) or false (F).

1. Air for the pressure regulator comes from the throat of the venturi.
2. The pressure regulator keeps a constant pressure in the control system regardless of the supply pressure from the venturi.
3. The pressure regulator sends pressure directly to work the pneumatic actuator.
4. Air from the pressure regulator that moves the pneumatic actuator is controlled by the servo controller.
5. The servo controller controls actuating pressure in the control system.

555

Frame 6

Solenoid valve 'A' (7) of the airflow control and shutoff valve is the ON-OFF control for this part. Solenoid valve 'A' is a DC part that is moved by aircraft power. When the air conditioning system is shut down the valve will be energized closed. Solenoid valve 'A' is spring loaded to the open position. For normal operation, power is not sent to the solenoid. Solenoid valve 'A' is controlled by the main air conditioning switch.

Complete the statements by listing the word(s) in parentheses that make the statement true.

1. Solenoid valve 'A' must be (energized; de-energized) to close the airflow control and shutoff valve.
2. If a power loss is experienced on the aircraft in flight, the airflow control and shutoff valve would (close; operate normally).
3. Solenoid valve 'A' is (energized; de-energized) when the air conditioning system is in operation.
4. Solenoid valve 'A' gets air straight from the (venturi; pressure regulator; servo controller).
5. When solenoid valve 'A' is energized, pressure at the throat of the venturi is more than; the same as; less than) pressure at the base of the venturi.

2389

Answers to Frame 6: 1. energized 2. operate normally 3. de-energized
4. servo controller 5. the same as

Frame 7

The pneumatic actuator (9) is a spring loaded, diaphragm operated device. It is hooked to a butterfly valve by linkage. The top half of the actuator is a pneumatic chamber. The bottom half has a vent to the atmosphere and has two springs. These springs force the diaphragm and linkage up to close the butterfly when air pressure is removed from the top side of the diaphragm. When air pressure from the servo controller goes through the de-energized solenoid valve 'A' to the top half of the pneumatic actuator, the diaphragm and linkage are forced down. This will cause the butterfly valve to open. When solenoid valve 'A' is energized, air pressure to the top half is shut off.

Use figure 2 as a guide, give the number in figure 2 that identifies each of the major components listed.

1. Pneumatic Actuator.
2. Servo Controller.
3. Solenoid Valve 'A'.
4. Venturi.
5. Pressure Regulator.
6. Filter.

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Answers to Frame 7: 1. (9) 2. (13) 3. (7) 4. (12) 5. (1) 6. (14)

Frame 8

The altitude compensator (5) is an aneroid controlled metering valve. The aneroid is an evacuated container that has a set internal pressure. With a rise in the altitude of the aircraft, the aneroid expands. At a set altitude, the aneroid will expand enough to let pressure from the control system to go in the left side of the secondary servo and force the diaphragm and metering valve to the right. This will let more air to flow to the pneumatic actuator and will cause the butterfly to open more and cause the flow of more air to the air conditioning package. On the other hand, as the aircraft comes down from high altitudes the aneroid contracts and the metering valve starts to close, thus reducing airflow to the secondary servo. The altitude compensator works with the servo controller to maintain a constant pneumatic pressure to give a constant air output.

Answer the statements as true (T) or false (F).

1. The altitude compensator will cause an increase in the flow of air to the air conditioning package at high altitudes.
2. As aircraft altitude increases, the aneroid in the altitude compensator contracts.
3. The metering valve of the altitude compensator controls the flow of air to the secondary servo diaphragm.
4. As the aneroid expands, the flow of air to the air conditioning package is reduced.
5. When the aneroid of the altitude compensator has expanded, the butterfly valve of the airflow control and shutoff valve will open.

2391

Answers to Frame 8: 1. T 2. F 3. T 4. F 5. T

Frame 9

Solenoid valve 'B' (2) is a direct acting valve that is spring loaded closed. Solenoid valve 'B' is used just for ground schedule operation. Just when the gas turbine compressor is used as the source of operating air for the air conditioning package. When solenoid valve 'B' is energized, a small amount of air is moved from the left side of the main servo section. The higher pressure on the right side of the main servo diaphragm will force the diaphragm and metering valve to the left and restrict the flow of air to the pneumatic actuator. When solenoid valve 'B' is energized the flow of air to the air conditioning package is stopped.

Answer the statements as true (T) or false (F). Use the foldout if necessary.

1. When the gas turbine compressor is used as the source of air for system operation, solenoid valve 'B' is de-energized.
2. When solenoid valve 'B' is energized, the metering valve of the servo controller will move to the left.
3. When in the ground schedule operation of the air conditioning system, solenoids 'A' and 'B' are both energized.
4. When solenoid valve 'B' is energized, the flow of air to the air conditioning system is stopped.
5. Throat pressure from the venturi is controlled by solenoid valve 'B' in the ground schedule operation.

559

Frame 10

The manual override control (6) is an emergency system. It will start or stop the flow of air to the pneumatic actuator should solenoid valve 'A' fail in the closed position. Air for this operation comes from the pressure regulator through the servo controller. An air line is used to send air to the pneumatic actuator. The manual override control is a cam and poppet that is moved by a TELEFLEX cable. When the handle of the teleflex control is placed to the open position, the cam is turned and will push on the right hand poppet and cause the poppet to open. Air is then sent to the top side of the pneumatic actuator. This will cause the butterfly valve to open. Once the butterfly is open the flow of air is metered by the servo controller to the pneumatic actuator. This maintains a constant flow of air to the air conditioning system. To shut the system down (OFF) the remote control is placed to the closed position; again, the cam is turned, and will let the right hand poppet close as the left poppet is opened by the cam. With the left hand poppet open air is dumped from the pneumatic actuator top side and the butterfly valve will close. This stops the flow of air to the air conditioning system.

Use figure 2 as a guide to answer the statements as true (T) or false (F).

1. A remote controlled cam and two poppets control the pneumatic actuator when solenoid valve 'A' fails in the closed position.
2. The airflow control and shutoff valve will not automatically keep a calibrated airflow when the manual override control is being used.
3. The manual override control bypasses solenoid valve 'A'.
4. The servo controller will meter the flow of air to the pneumatic actuator when the manual control is being used.
5. The teleflex cable directly controls the poppet valves of the manual override control.

Frame 11

From the right hand column, pick the statement that best describes the purpose or operation of each of the components in the left hand column.

- | | |
|----------------------------|---|
| 1. Venturi | A. Increases airflow to the air conditioning package at high altitude. |
| 2. Solenoid Valve 'A' | |
| 3. Servo Controller | B. Provides differential pressure for the control system. |
| 4. Manual Override Control | C. Controls airflow to the pneumatic actuator when solenoid valve 'A' is inoperative. |
| 5. Pressure Regulator | |
| 6. Solenoid Valve 'B' | D. Meters airflow to the pneumatic actuator. |
| 7. Altitude Compensator | E. Reduces pressure in the control system. |
| 8. Pneumatic Actuator | F. Controls the amount of airflow to the air conditioning system. |
| | G. Turns the air conditioning system ON and OFF. |
| | H. Is used to control system operation when the aircraft is on the ground. |

2394

Answers to Frame 11: 1. B 2. G 3. D 4. C 5. E 6. H 7. A 8. F

Frame 12

Now, just as a review, write the names of the major components that corresponds to the numbers in parentheses. Use figure 2, if you must, to help you name all of them.

1. (6)
2. (13)
3. (5)
4. (1)
5. (9)
6. (14)
7. (12)
8. (7)
9. (2)

Oh, yes! You can check your responses to this frame at the top of the next page.

2395

Answers to Frame 12:

- | | |
|----------------------------|-----------------------|
| 1. Manual Override Control | 5. Pneumatic Actuator |
| 2. Servo Controller | 6. Filter |
| 3. Altitude Compensator | 7. Venturi |
| 4. Pressure Regulator | 8. Solenoid Valve 'A' |
| | 9. Solenoid Valve 'B' |

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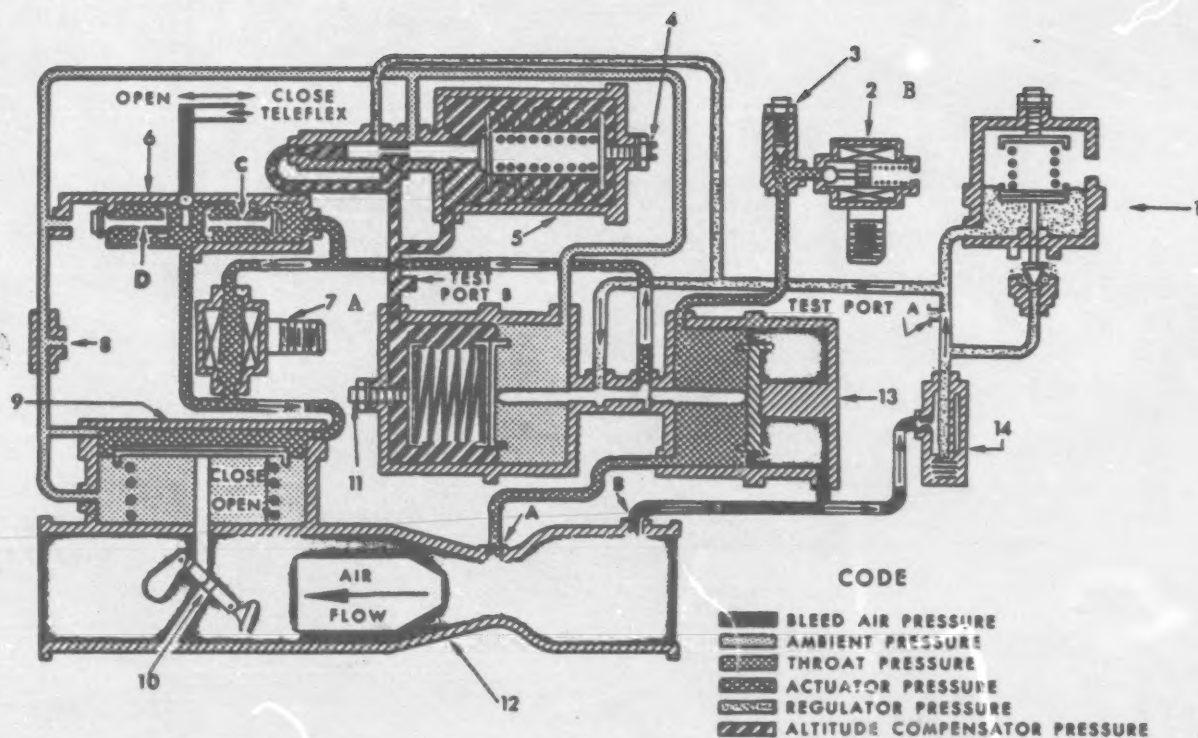


Figure 2. Airflow Control and Shutoff Valve.

PRINCIPLES OF AIRFLOW CONTROL AND SHUTOFF VALVE

Frame 1

1. _____ 4. _____

2. _____ 5. _____

3. _____

Frame 5

1. _____ 4. _____

2. _____ 5. _____

3. _____

Frame 9

1. _____ 4. _____

2. _____ 5. _____

3. _____

Frame 2

1. _____ 4. _____

2. _____ 5. _____

3. _____

Frame 6

1. _____

2. _____

3. _____

4. _____

5. _____

Frame 10

1. _____ 4. _____

2. _____ 5. _____

3. _____

Frame 3

1. _____ 4. _____

2. _____ 5. _____

3. _____

Frame 11

1. _____ 5. _____

2. _____ 6. _____

3. _____ 7. _____

4. _____ 8. _____

Frame 4

1. _____

2. _____

3. _____

4. _____

5. _____

Frame 7

1. _____ 4. _____

2. _____ 5. _____

3. _____ 6. _____

Frame 8

1. _____ 4. _____

2. _____ 5. _____

3. _____

Frame 12

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____



Technical Training

Aircraft Environmental System Mechanic

BENCH TESTING ELECTRIC MOTOR ACTUATED VALVES

22 September 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

2399

This workbook contains practical work assignments for you to accomplish in conjunction with your study assignments. Complete each problem or work assignment in the sequence given and it will aid you in understanding and retaining the key points covered in each assignment.

This supersedes 3ABR42231-WB-312, 9 February 1973.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 2

BENCH TESTING ELECTRIC MOTOR ACTUATED VALVES

OBJECTIVES

The objectives are listed at the beginning of each section.

EQUIPMENT

Each section has an equipment list.

PROCEDURE

The procedures that are used to complete this workbook are listed in each section. The first three sections are for the bench check of electric motor actuated valves.

Section I - BENCH CHECK OF TWO AND ONE-HALF INCH DIAMETER MODULATING ELECTRIC AIR SHUTOFF VALVE

OBJECTIVES

After completing Section I of this workbook, you will be able to:

1. Interpret operating specifications for valve part number (P/N) 104248-3 from applicable technical order.
2. Bench check the butterfly valve for correct electrical operation.
3. Bench test the butterfly valve for excessive port leakage.

Standard of performance:

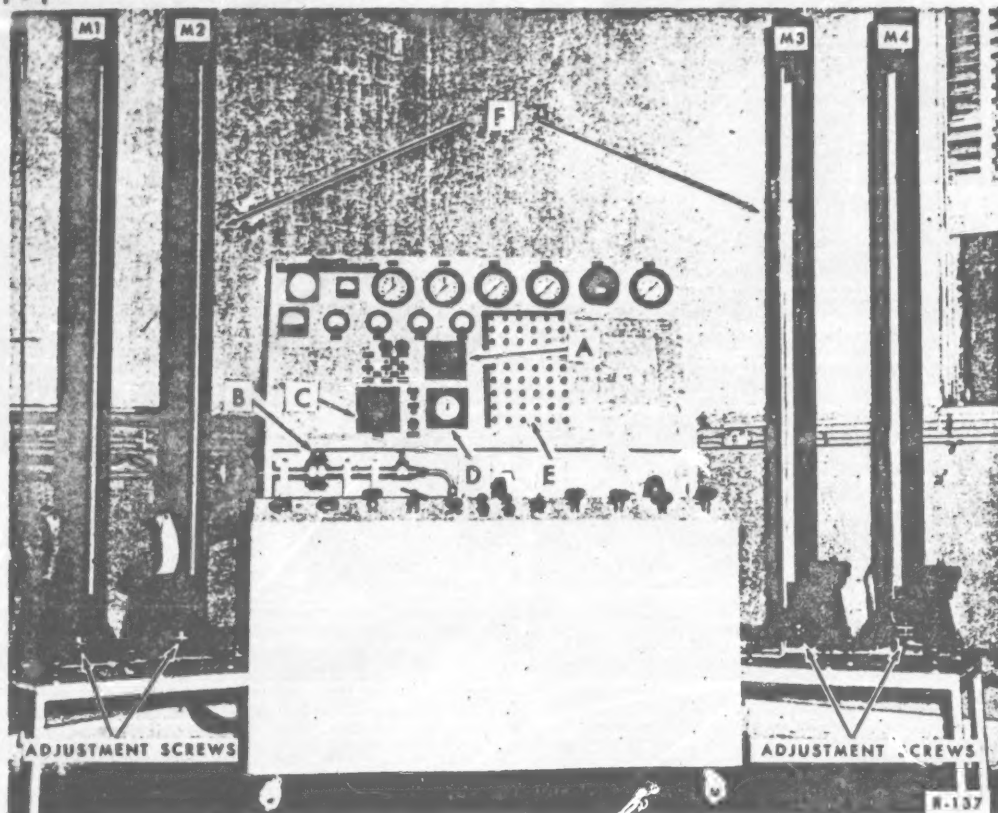
Your performance will be evaluated by an instructor using a criterion referenced checklist. A minimum of 70% accuracy must be made for satisfactory completion of the objectives.

EQUIPMENT

	Basis of Issue
Electrical Pneumatic Trainer No. 3038	1/2 students
Valve Part No. 104248-3	1/student
Technical Order 9P5-14-3-3	1/student
TO Index	1/student

PROCEDURE

1. Use trainer number 3038 to make a port leakage test of an electric air shutoff valve. This check is to find how much air leaks past the valve butterfly when it is in the closed position. Use figure 1 to find the following items and familiarize yourself with the trainer.



- | | |
|-------------------------------------|-----------------------------|
| A. Voltage Adjustment Potentiometer | D. Precision Timer |
| B. Low Capacity Flowmeter | E. Pneumatic Patching Panel |
| C. Electrical Patching Panel | F. Manometers |

Figure 1. Trainer No. 3038 - Electric Pneumatic Timer.

a. Voltage adjustment potentiometer (A). This unit adjusts the DC voltage on the trainer.

b. Low capacity orifice flowmeter (B). An orifice is put in this part of the trainer to keep a differential pressure at the manometers.

c. Electrical patching panel (C). Electrical wires will be hooked from this panel to the valve under test.

d. Precision timer (D). Times the cycling time of the unit under test. Press down on the black lever to reset before each test.

e. Pneumatic patching panel (E). Hoses will be hooked from this panel to the valve under test.

2402

f. Manometers (F). These are pressure measuring devices and will be taught later.

Caution: At this point make sure that you have removed your jewelry.

2. Go to equipment locker number 2 and get a shutoff valve, Part Number 104248-3.

a. Use the indexes on the TO file cabinet to find (by part number) the Parts Breakdown Technical Order for this valve.

b. Answer the following question.

(1) What is the correct TO number? _____

3. Get the correct TO from the TO file cabinet.

a. In the TO find the operating specifications for valve, Part Number 104248-3, and complete the following statements.

(1) Operating inlet air pressure is _____.

(2) Operating voltage is _____.

(3) Operating current (amperage draw) is _____.

Note: The ammeters AØ, BØ, and CØ are calibrated in milliamps. (.1 amp = 100 milliamps.)

(4) Cycling time open to close is _____.

(5) Cycling time close to open is _____.

b. Visually inspect the valve for the following:

(1) Corrosion on the housing.

(2) Cracked valve housing.

(3) Damaged threads on the cannon plug.

QUESTION

What does the TO say about removing minor nicks, scratches, burrs and mild corrosion from steel parts? _____

4. Trainer Preparation.

a. Make sure that each switch is in the OFF position. Switch S-5 does not have to be moved at this time.

2403

b. Plug the trainer power cables in the proper wall receptacle. Make sure that all circuit breakers on the left end of the trainer are pushed IN.

5. Electrical Hookup.

a. Follow the hookup shown in foldout 1 near the end of this workbook.

b. Hook the connector plug of the valve to the correct electrical pins on the trainer electrical patching panel.

c. Use the trainer wires to make these connections.

Caution: At this point check the connections before you go to the next step. This prevents the danger of a short circuit due to crossed wires. Have the instructor check your hookup.

6. Operation of the Valve.

a. Place switch S-1 to the ON position. This turns on the power to the trainer. Place switch Ø SEL to 1Ø. The AC voltmeter should show 110 to 120 volts. The DC voltmeter should show 24 to 28 volts. If you do not have these readings, recheck your hookup and/or the voltage adjustment potentiometer (see (A) in figure 1). The potentiometer should be set to full increase.

b. Check the valve position to find if the valve is opened or closed.

(1) If the valve is open, place switch S-5 to the CLOSE position. The valve should close.

(2) If the valve is closed, place switch S-5 to the OPEN position. The valve should open.

c. Complete the following statements. First put the valve in position to make the check. Take the readings from the correct meters or gages on the trainer.

Note: Reset the timer before operating the valve.

(1) Place switch S-5 to the open position.

(2) While valve is operating, move Ø SEL (phase selector) switch to A Ø, B Ø and then C Ø in turn. Read the AC voltmeter. Be sure to take the readings from each ammeter and AC voltmeter before the valve reaches the OPEN position.

(3) Operating voltages are: A phase _____,
B phase _____, C phase _____.

(4) Operating current (amperage draw) for each phase is: A phase _____, B phase _____, C phase _____.

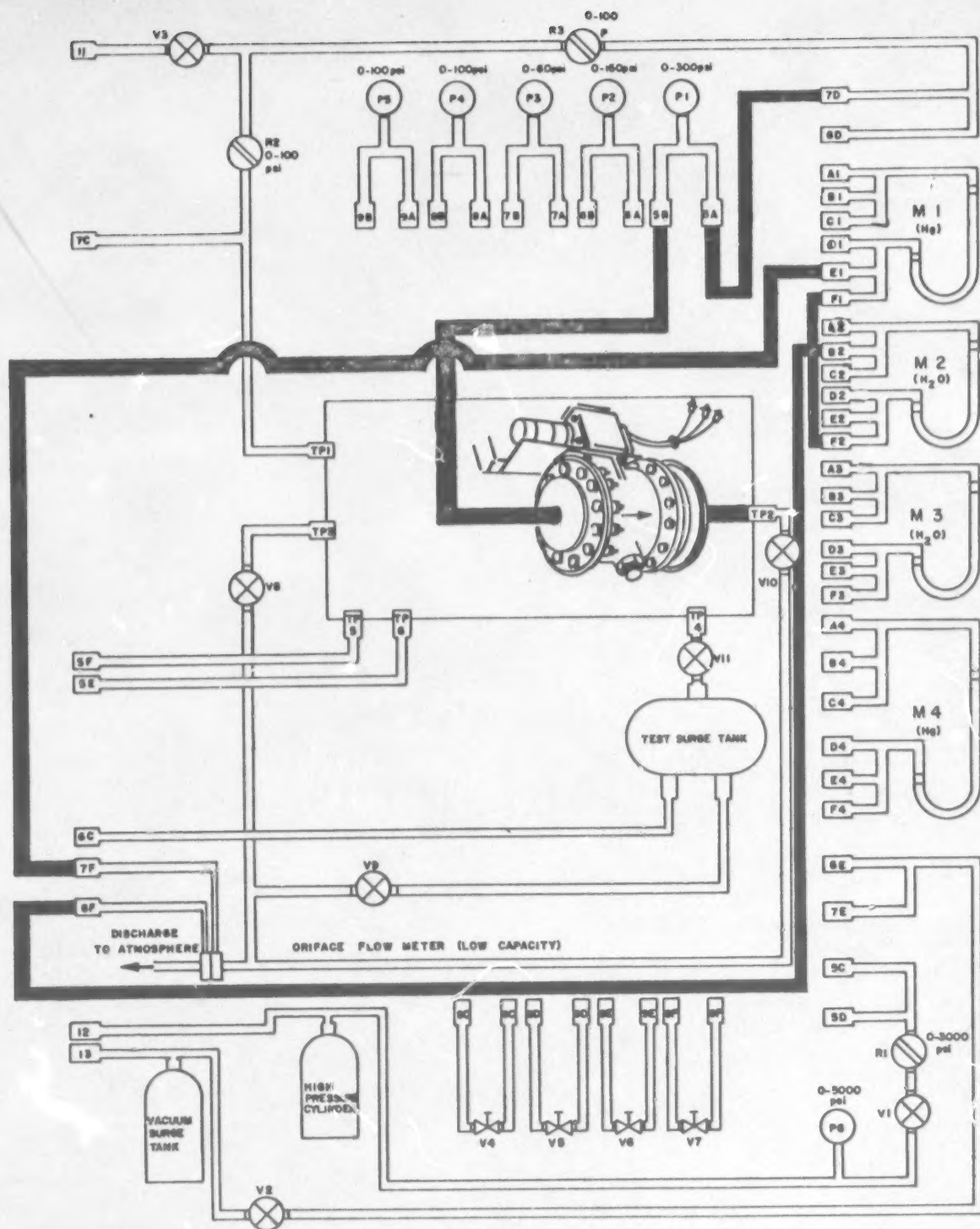


Figure 2. Test Facility Pneumatic Schematic.

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(5) Cycling time from close to open is _____ seconds.

(6) Now place switch S-5 to the CLOSE position.

(7) While valve is operating move Ø SEL (phase selector) switch to A Ø, B Ø and then C Ø in turn. Read the AC voltmeter. Be sure to take the readings from each ammeter and AC voltmeter before the valve reaches the CLOSED position.

(8) Operating voltages are: A phase _____, B phase _____, C phase _____.

(9) Operating current (amperage draw) for each phase is A phase _____, B phase _____, C phase _____.

(10) Cycling time from open to close is _____ seconds.

(11) Does the valve operate according to TO specifications? _____

(12) Place switch S-1 to the OFF position.

7. Port Leakage Hookup.

a. Figure 2 gives the proper way to hook the valve to the trainer. The heavy, black lines show how to hook each hose in order to make this check.

b. Make the necessary connections using the hoses provided in the bottom of the trainer cabinet.

EXAMPLE: Hook one end of a hose to connection 7D on the trainer and connect the other end of the same hose to connection 5A. Continue until each hose is connected. DO NOT use a wrench to tighten the "B" nuts (hose connections) as finger tightness is sufficient for this test.

c. Check the valves and regulators on the trainer to be sure they are in the correct positions.

(1) Valves V8 and V9 are closed. (Full clockwise)

(2) Valve V10 is open. (Full counterclockwise)

(3) Turn regulators R2 and R3 counterclockwise until they turn freely. DO NOT turn the regulators too far or they will fall out and cause loss of air pressure.

d. At this point let us take a few minutes to read about manometers. These instruments are used for measuring differential or absolute pressures. There are several types of liquids used in manometers. Oil, water (H₂O) or mercury (Hg) is used. The M-1 manometer is filled with mercury and the M-2 manometer is filled with water.

e. Manometer Settings.

(1) Place the M-1 manometer on the inches mercury scale. The scale starts at 28 Hg. This is the manometer on the far left as you face the trainer. Turn the scale (set the scale by turning the knobs at the bottom of each manometer) so that the top of the mercury bubbles (meniscus) is set to the barometric pressure of the day. Since we have no barometer here in the laboratory set the scale at 30 Hg which is very close to the average daily barometric pressure.

(2) Place the M-2 manometer on the inches water scale so that the bottom of the bubble is on zero.

(3) Remove the steel cap from the 1 1/4 inch pipe. This pipe comes out from the left end of the trainer. Air can now flow through the orifice to the atmosphere.

8. Port Leakage Test.

a. If you have followed the instructions carefully up to now, the position indicator on the valve should show full CLOSED position.

b. Turn V-3 full counterclockwise. Air pressure is now at the trainer.

c. Valve V-10 should have been opened. This gives a path for the exhaust of air from the shutoff valve.

d. Turn R-3 clockwise until 70 psig shows on pressure gage P-1. DO NOT let the water in manometer M-2 to rise above 55 inches. This is to keep you from accidentally pushing the water out of the top of the manometer.

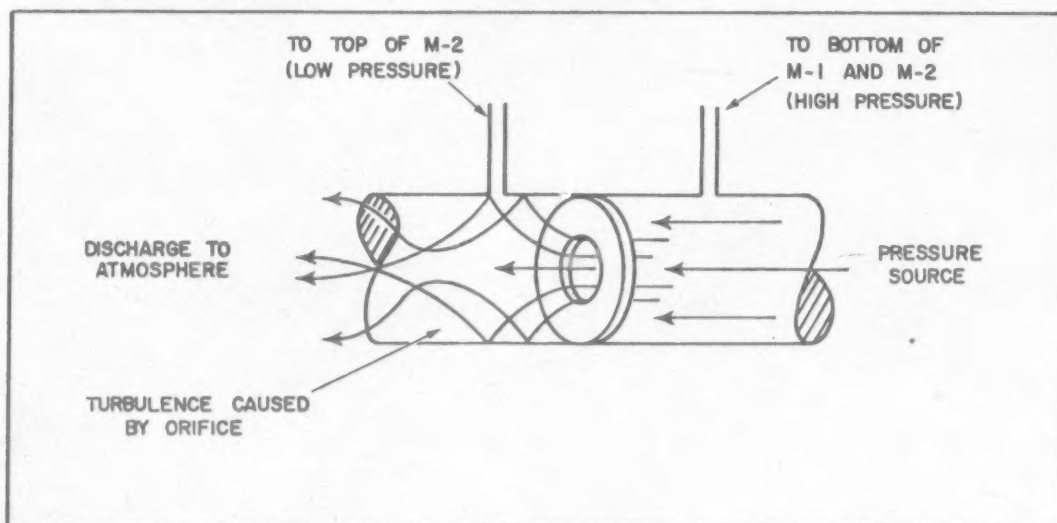


Figure 3. Typical Orifice in a Duct.

e. Trace the air flow through the trainer and valve (figure 2). Air in the trainer flows through V-3 and R-3 to connection 7D from 7D through pressure gage P1 and then to the valve. Even though the valve is closed, some air leaks through and goes through V-10 and on to the orifice. Air flow from the upstream side of the orifice goes through connection 7F to E1. From E1 air flows to the bottom of M-1 and at the same time air flows through fitting F1 to F2 and to the bottom of M-2. The mercury manometer (M-1) now reads the absolute pressure that goes through the valve and to the orifice. This high pressure will push the water up in manometer M-2. After the air goes through the orifice, the pressure will drop due to turbulence caused by the restriction (see figure 3). This low pressure air flows through fitting 6F to B2 and in the top of manometer M-2 and tries to push the water down. The two air flows meet and stabilize in M-2. This is where the differential pressure reading is made. You will use this reading (value) later on to find if the valve is leaking too much.

f. What is the reading on the M-1 manometer? _____
Keep in mind your answer must be in inches Hg.

g. What is the reading on the M-2 manometer? _____
This time your answer must be in inches H₂O.

Note: See if the instructor wants you to use these values.

h. The next step is to find if the leakage in the valve is within normal limits. There is some math used here so, before we start figuring, first drop pressure on the trainer to be safe.

i. Turn regulator R-3 counterclockwise until it turns freely and pressure gage P-1 drops to zero.

j. Close shutoff valve V-3 (full clockwise).

k. The amount of air that goes through the closed butterfly is measured in pounds per minute (PPM). The formula used to determine the amount of leakage is as follows:

$$\Sigma \Delta P = \frac{17.35 \times P_1}{T_1 + 460} \times \Delta P$$

1. Do not panic now! Let us see just what all of this means. First, $\Sigma \Delta P$ is called SIGMA, DELTA, P. The number on the right side of the equal sign is called the conversion factor. The first thing that must be done is to make this conversion factor into a single number. We do this by converting all of the unknown figures such as P_1 , T_1 , and ΔP , into known ones. P_1 is the M-1 manometer reading. ΔP is the M-2 manometer reading (the difference in pressure between one side of the orifice and the other). T_1 is the temperature of the air.

Note: Until the trainer is equipped with a thermometer, you will need to use the one in the window at the end of the laboratory.

m. Rewrite the formula with the known figures in place **2408**
of the unknowns. Solve a problem just for practice.

n. Assume we have just made some readings. M-1 manometer reads 33, M-2 manometer reads 26 and the temperature is 68°F.

STEP 1: WRITE THE FORMULA.

$$\Sigma \Delta P = \frac{17.35 \times P_1}{T_1 + 460} \times \Delta P$$

STEP 2: REWRITE THE FORMULA USING KNOWN NUMBERS IN PLACE OF UNKNOWN ONES.
 $P_1 = 33, \Delta P = 26, T_1 = 68$

$$\Sigma \Delta P = \frac{17.35 \times 33}{68 + 460} \times 26$$

STEP 3: MULTIPLY 17.35 by P_1 (33). DON'T FORGET THAT DECIMAL POINT.

$$\begin{array}{r} 17.35 \\ \times 33 \\ \hline 5205 \\ 5205 \\ \hline 572.55 \end{array}$$

STEP 4: NOW, ADD 460 TO T_1 (68).

$$\begin{array}{r} 460 \\ +68 \\ \hline 528 \end{array}$$

STEP 5: AT THIS POINT, REWRITE THE FORMULA TO SEE WHAT YOU HAVE THUS FAR.

$$\Sigma \Delta P = \frac{572.55}{528} \times 26$$

STEP 6: DIVIDE THE BOTTOM HALF OF THE FRACTION INTO THE TOP HALF. CARRY OUT TO ONLY TWO DECIMAL PLACES.

$$\begin{array}{r} 1.08 \\ 528 \overline{) 572.55} \\ \underline{528} \\ 4455 \\ \underline{4224} \\ 231 \end{array}$$

AGAIN, REWRITE THE FORMULA.

$$\Sigma \Delta P = 1.08 \times 26$$

STEP 7: MULTIPLY. ONCE AGAIN, DON'T FORGET THE DECIMAL POINT.

$$\begin{array}{r} 1.08 \\ \times 26 \\ \hline 648 \\ 216 \\ \hline 28.08 \end{array}$$

STEP 8: THE ANSWER IS ROUNDED OFF TO THE NEAREST WHOLE NUMBER MAKING IT AN EVEN 28. THEREFORE, $\Sigma \Delta P = 28$ WHICH IS THE FINAL CONVERSION FACTOR.

STEP 9: Figure 4 is a flow chart that will show the allowable leakage of a valve when the leakage test is made using an .150 orifice. Since the 3038 trainer has this type of an orifice, let us see how the flow chart works.

(1) Find the conversion factor (28) on the left side of the chart. Follow that horizontal line to the right until it intersects with the diagonal line.

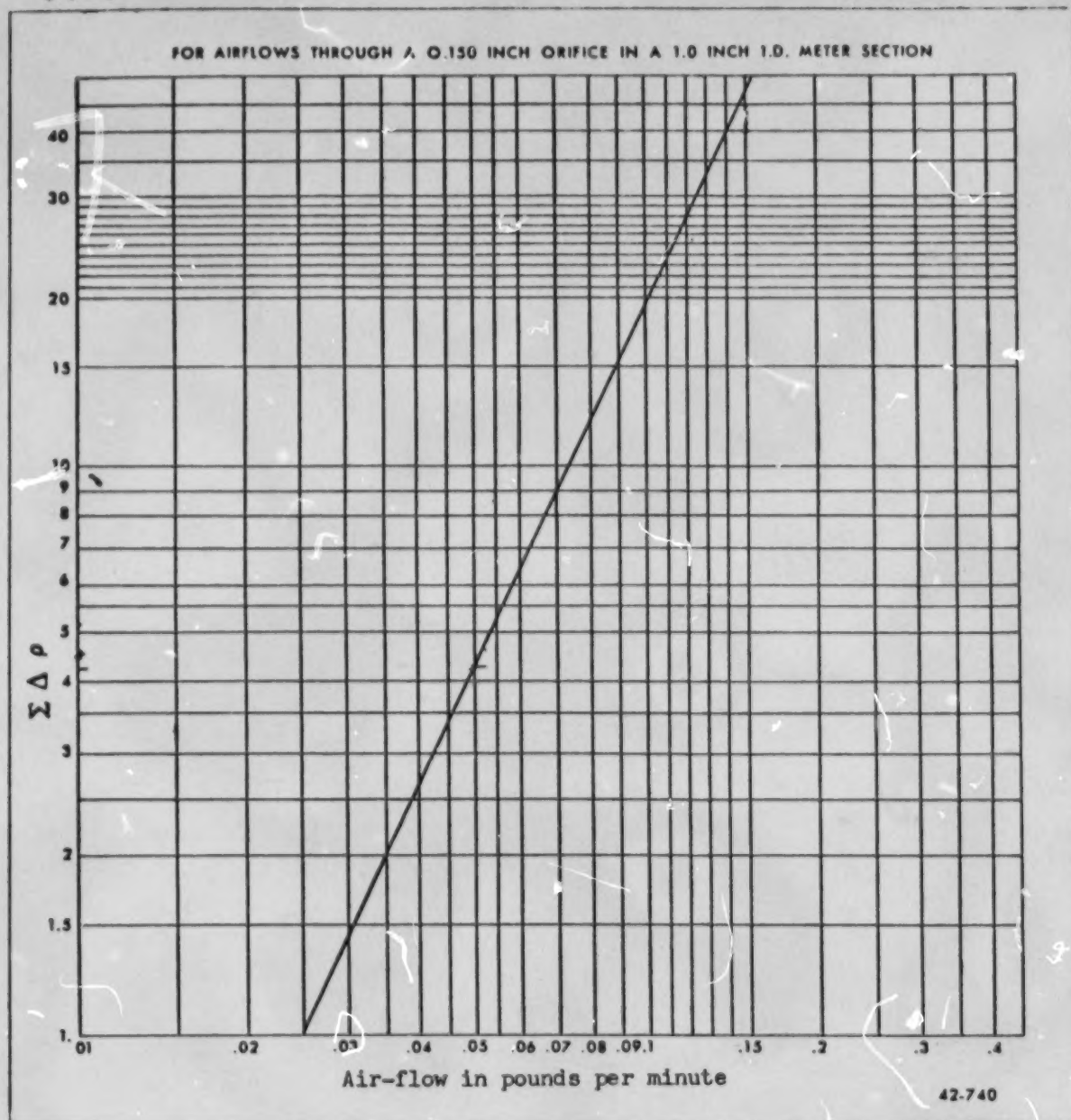


Figure 4. Air Flow Chart.

(2) At the point where the two lines intersect, follow the vertical line to the bottom of the chart. As you can see, the line ends at the bottom of the chart on the number .12. This means that the valve under test is leaking at the rate of .12 PPM.

(3) Now that you know how much the valve is leaking (.12 PPM), go to the TEST PROCEDURES section of the applicable TO. Find the maximum allowable leakage for that valve. If the leakage is too much, the TO will tell you what to do.

o. Use the same formula and the same procedure to find ^{24/0} the port leakage of the valve that you are testing.

Note: Different valves have different allowable port leakages. The procedure for port leakage testing is the same for all valves. Read the TEST PROCEDURES section of the applicable TO to find the amount of allowable port leakage.

p. Use the TO to complete the following statements.

(1) The TO shows that the maximum allowable port leakage for the valve is _____ pounds per minute.

(2) Is the valve leaking too much? _____

(3) If leakage is more than the specified amount, _____ or fix other causes of leakage before going to the other tests.

Note: At this time have the instructor check your work.

q. Conclusion of leakage test.

(1) Disconnect and plug the end of each hose. Store them in the bottom of the trainer cabinet.

(2) Remove all electrical wires and lay them to one side for the next project.

(3) Cap all ports and cover the electrical connectors on the valve. Stow the valve in equipment locker number 2.

(4) If any of the equipment (hoses, wires, nuts, caps, plugs) was damaged or missing, notify the instructor and he will see that corrections are made.

(5) If no discrepancies were noted, start on the next project.

Section II - BENCH CHECK OF THE MOTOR ACTUATED BUTTERFLY SHUTOFF VALVE ASSEMBLY

OBJECTIVES

After completing Section II of this workbook, you will be able to:

1. Interpret operating specifications for valve P/N 121535-1 from the applicable technical order.
2. Bench check the butterfly valve for correct electrical operation.

Standard of performance:

Your performance will be evaluated according to an instructor checklist. A minimum of 70% accuracy must be obtained for satisfactory completion of the objectives.

EQUIPMENT

	Basis of Issue
Electrical Pneumatic Trainer No. 3038	1/2 students
Valve Part No. 121535-1	1/student
Technical Order 15A2-2-52-83	1/student
TO Index	1/student

PROCEDURE

1. Use trainer number 3038 to bench check a motor actuated butterfly shutoff valve. This check is to find if the valve meets the technical order operating specifications and to check the butterfly valve for correct electrical operation.

2. Go to equipment locker number 2 and get the shutoff valve assembly with the part number 121535-1.

a. Use the indexes on the TO file cabinet and find (by part number) the Parts Breakdown Technical Order for this valve.

b. Answer the following question.

(1) What is the correct TO number? _____

3. Get the correct TO from the TO file cabinet.

a. In the TO find the operating specifications for valve part number 121535-1 and complete the following statements.

(1) Operating pressure differential across the butterfly at +570°F is _____.

(2) Operating voltage is _____.

(3) Stall current at 26V DC and +21°C is _____.

24/2

(4) Operating time from open to close is _____.

(5) Operating time from close to open is _____.

b. Visually inspect the valve for the following:

(1) Corrosion on the butterfly and housing.

(2) Cracked valve housing.

(3) Damaged threads on the electrical connector plug.

QUESTION

What should be done if any component of the shaft assembly or disc assembly shows wear or damage beyond minor repair? _____

4. Trainer Preparation.

a. Make sure that each switch is in the OFF position.

b. The trainer should still be hooked to the proper wall receptacle from the previous test.

5. Electrical Hookup.

a. Follow the hookup shown on foldout 2.

b. The connections will be made with the wires at the trainer.

c. Hook the connector plug of the valve to the correct electrical pins on the trainer electrical patching panel.

Caution: At this point check the connections before you go to the next step. This prevents the danger of a short circuit due to crossed wires. Have the instructor check your hookup.

6. Operation of the valve.

a. Place switch S-1 to the ON position. This turns on the power to the trainer. Place switch $\emptyset$ SEL to 1 $\emptyset$. The AC voltmeter should show 110 to 120 volts. The DC voltmeter should show 24 to 28 volts. If you do not have these readings, recheck your hookup and/or the voltage adjustment potentiometer (see (A) in figure 1). The potentiometer should be set to full increase.

b. Check the valve position indicator to see if the valve is opened or closed.

(1) If the valve is open, place switch S-2 to the #2 position and the valve should close.

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(2) If the valve is closed, place switch S-2 to the #3 position and the valve should open.

c. Complete the following statements. First put the valve in position to make the check. Take the readings from the correct meters or gages on the trainer.

Note: Reset the timer before operating the valve.

(1) Cycling time from open to close is _____ seconds.

(2) Operating voltage is _____ volts DC. Be sure to read the DC voltmeter.

(3) Operating current (amperage draw) is _____ amps. Be sure to read the DC ammeter.

Note: Reset the timer.

(4) Place switch S-2 to the appropriate position and complete the following statements.

(5) Cycling time from close to open is _____ seconds.

(6) Operating voltage is _____ volts DC. Be sure to read the DC voltmeter.

(7) Operating current (amperage draw) is _____ amps. Be sure to read the DC ammeter.

(8) Does the valve operate according to the TO specifications? _____

(9) Place switch S-1 to the OFF position.

7. Disconnect the valve from the trainer.

a. Remove the electrical wires connecting the valve to the trainer and lay them aside for the next project.

b. Cap all ports and cover electrical connectors on the valve. Stow the valve in equipment locker number 2.

c. If any of the equipment (wires, caps, plugs) was damaged or missing, notify the instructor and he will see that corrections are made.

8. If no discrepancies were noted, go to the next project.

Section III - BENCH CHECK OF THE POWER OPERATED BUTTERFLY VALVE

OBJECTIVES

After completing this section of the workbook, you will be able to:

1. Interpret operating specifications for valve P/N 657T100-5 from the applicable technical order.
2. Bench check the butterfly valve for correct electrical operation.
3. Indicate a working knowledge of the various tasks by answering the questions in this workbook.

Standard of performance:

Your performance will be evaluated according to an instructor checklist. A minimum of 70% accuracy must be obtained for satisfactory completion of the objectives.

EQUIPMENT

	Basis of Issue
Electrical Pneumatic Trainer No. 3038	1/2 students
Valve Part No. 657T100-5	1/student
Technical Order 15A2-2-92-3	1/student
TO Index	1/student

PROCEDURE

1. Use trainer number 3038 to bench check a power operated butterfly valve. This check is to find if the valve meets the technical order operating specifications and to check the butterfly valve for correct electrical operation.

2. Go to equipment locker number 2 and get the valve assembly with the part number 657T100-5.

a. Use the indexes on the TO file cabinet and find (by part number) the Parts Breakdown Technical Order for this valve.

b. Answer the following question.

(1) What is the correct TO number? _____

3. Get the correct TO from the TO file cabinet.

a. In the TO find the operating specifications for the valve and complete the following statements.

(1) Rated operating pressure is _____.

(2) Operating voltage is _____.

(3) Running current is _____.

(4) Stroke time should be _____.

b. Visually inspect the valve for the following:

(1) Corrosion on the butterfly and housing. What should you do if corrosion is found? _____

(2) Heat discoloration on painted surfaces. What would be done to repair the painted surfaces? _____

(3) Damaged threads on the connector plug. How are they repaired? _____

4. Trainer Preparation.

a. Make sure that each switch is in the OFF position.

b. The trainer should still be hooked to the proper wall receptacle from the previous test.

5. Electrical Hookup.

a. Follow the hookup shown on foldout 3.

b. The connections will be made by using the wires at the trainer.

c. Hook the connector plug of the valve to the correct electrical pins on the trainer electrical patching panel.

Caution: At this point check your connections before going to the next step. This prevents the danger of a short circuit due to crossed wires. Have the instructor check your hookup.

6. Operation of the valve.

a. Place switch S-1 to the on position. The AC voltmeter should show 110 to 120 volts. The DC voltmeter should show 24 to 28 volts. If you do not have these readings, read paragraph 6a, section II for corrective action.

b. Check the valve position indicator to find if the valve is opened or closed.

Note: Reset the timer before operating the valve.

24/6

(1) If the valve is open, place switch S-4 to the close position. The valve should close. If the valve was closed, leave it there.

c. Complete the following statements. First put the valve in position to make the check. Take the readings from the correct meters or gages on the trainer. Place switch S-4 to the open position.

(1) Cycling time from close to open is _____ seconds.

(2) Operating voltage is _____ volts. Be sure to read the AC voltmeter.

(3) Running current is _____ amps.

d. Set the Ø SEL switch to 1Ø and read the ammeter labeled SGL Ø.

Note: Reset the timer before the next operation.

e. Place switch S-4 to the CLOSED position.

(1) Cycling time from open to close is _____ seconds.

(2) Operating voltage is _____ volts. Be sure to read the AC voltmeter.

(3) Running current is _____ amps.

f. Set the Ø SEL switch to 1Ø and read the ammeter labeled SGL Ø.

g. Place switch S-4 to the CLOSE position.

h. Does the valve operate according to the TO specifications? _____. If it does, very good. If the valve will not move, what is the probable cause? _____

What remedy should be taken? _____

1. Place switch S-1 to the OFF position.

7. Disconnect the valve from the trainer.

a. Remove the electrical wires connecting the valve to the trainer and lay them aside for the next project.

b. Cap all ports and cover electrical connectors on the valve. Stow the valve in equipment locker number 2.

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c. If any of the equipment (wires, caps, plugs) was damaged or missing, notify the instructor and he will see that corrections are made.

8. If no discrepancies were noted, proceed to the next project.

Section IV - BENCH CHECK OF A TWO AND ONE-HALF INCH DIAMETER PNEUMATIC SHUTOFF VALVE

OBJECTIVES

After completing this section of the workbook, you will be able to:

1. Interpret operating specifications for valve P/N 122142 from the applicable technical order.

- a. Solenoid operation.
- b. Resistance check.
- c. Maximum voltage check.

Standard of performance:

Your performance will be evaluated according to an instructor checklist. A minimum of 70% accuracy must be obtained for satisfactory completion of the objectives.

EQUIPMENT

Electrical Pneumatic Trainer No. 3038
Valve Part No. 122142
Technical Order 9P5-5-59-43
Technical Order 1B-52B-06
TO Index

Basis of Issue
1/2 students
1/student
1/student
1/student
1/student

PROCEDURE

1. Use trainer number 3038 to bench check a two and one-half inch diameter pneumatic shutoff valve. This check is to find if the valve meets the technical order operating specifications and to check the solenoid and butterfly for correct operation.

2. Go to equipment locker number 2 and get the valve assembly with the part number 122142.

a. Use the indexes on the TO file cabinet and find (by part number) the Parts Breakdown Technical Order for this valve.

b. Answer the question.

(1) What is the correct TO number? _____

3. Get the correct TO from the TO file cabinet.

a. In the TO find the operating specifications for the 24/8 valve and complete the statements.

- (1) Valve normal position is _____.
- (2) The operating voltage requirement is _____.
- (3) The operating current is _____.
- (4) Actuating time closed to open or open to closed should not exceed _____ maximum.

b. If you had to disassemble the valve for repair, all parts would have to be cleaned and inspected. Let us see what the TO says about the cleaning process.

- (1) All parts, except those to be replaced, are cleaned with _____ and dried thoroughly.
- (2) Air passages are cleaned thoroughly with _____.
- (3) Before installing new bearings, they should be cleaned with _____.

c. Inspection: Using the TO, refer to paragraph 4 and figure 8 to make the following checks.

Note: You will need an ohmmeter for one of these checks so go to equipment locker number 1 and get a multimeter with the number ME-77 C/U.

(1) Use the ohmmeter to measure the resistance of the solenoid. This check is made across pins A and B of the valve. What reading did you get? _____

(2) The TO states that the resistance must be between _____ and _____ ohms. If the resistance of the solenoid is not within this range the solenoid would have to be replaced. Once the resistance check is made, disconnect the multimeter and return it to equipment locker number 1.

(3) Check maximum operating voltage as follows: Use the electrical wires at the trainer. Hook solenoid pin (A) to trainer pin (F). Solenoid pin (B) is hooked to trainer pin (R). Turn switch S-1 to the ON position. Turn the voltage adjustment potentiometer to full decrease. Turn switch S-2 to position 3. This will energize the solenoid. SLOWLY turn the voltage adjustment potentiometer toward full increase until you hear a click in the solenoid.

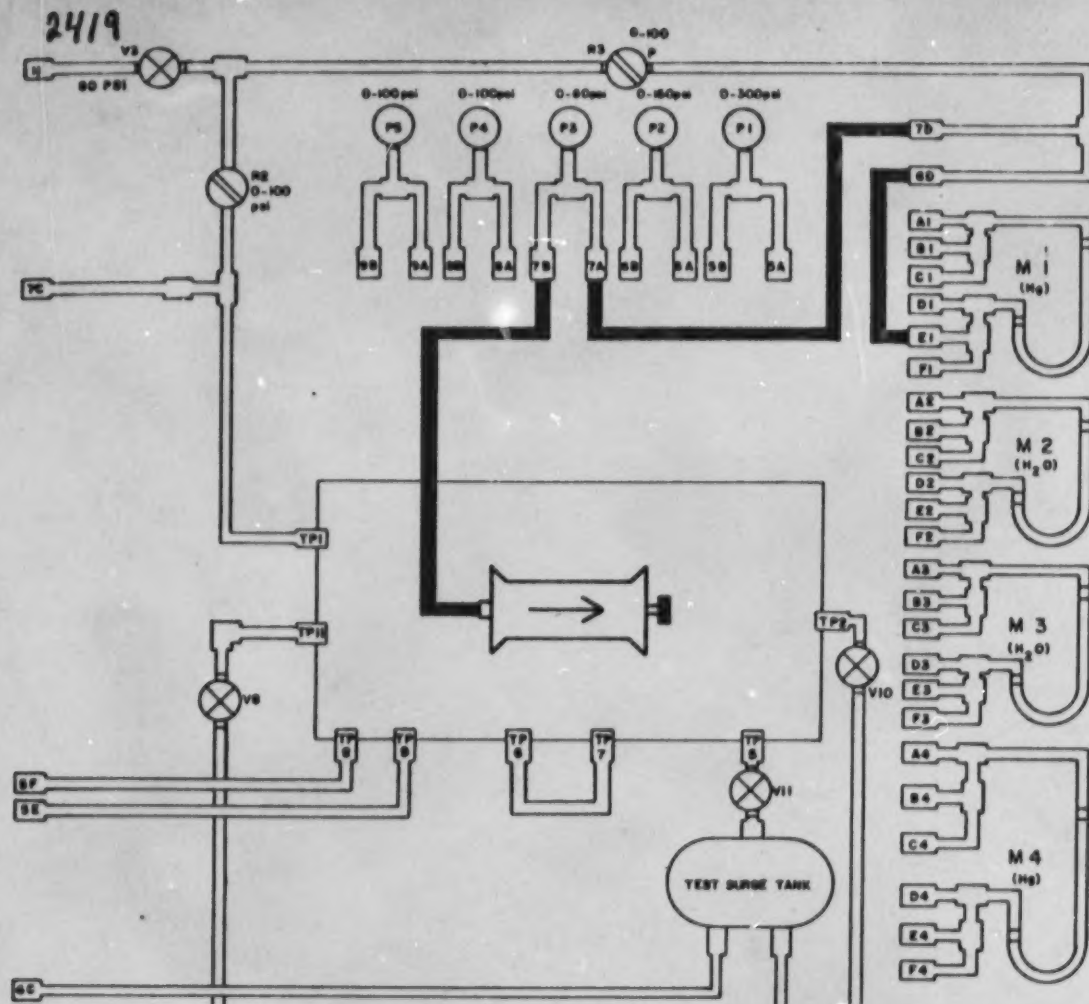


Figure 5. Pneumatic Valve Test Setup.

(4) Read the DC voltmeter at the sound of the click. What is the voltage? _____. The technical order lists the maximum voltage required to energize the solenoid as _____.

(5) Turn switches S-1 and S-2 to the OFF position and the voltage adjustment potentiometer to full increase in that order.

d. Operational Check.

(1) Using figure 5, hook each pneumatic hose (heavy dark lines) to the valve and the trainer. M-1 manometer scale should be set to read zero on the inches of mercury scale.

(2) Place switch S-1 to ON.

(3) Open valve V-3.

(4) Slowly build pressure by turning regulator R-3 ²⁴²⁰ clockwise until the valve indicator shows closed. This should happen as soon as pressure is applied. If not, your hookup must be wrong.

(5) Once the valve is closed, reduce the pressure by turning regulator R-3 counterclockwise until manometer M-1 shows zero.

(6) Place switch S-2 to position 3.

Caution: You MUST keep an eye on manometer M-1 during the next step or you may blow the mercury out of the top of the manometer. BE CAREFUL!

(7) With regulator R-3, SLOWLY build pressure and closely watch the valve indicator. When the indicator shows that the valve is open, stop applying pressure.

(8) The valve should have opened between 9.0 and 14.0 inches of Hg.

(9) What was the manometer reading? _____

(10) How is minimum opening pressure adjusted? _____

(11) Reduce the pressure to zero by turning regulator R-3 counterclockwise.

(12) How much time is allowed for the butterfly to open and close? _____

(13) Disconnect the line to manometer M-1 and cap the connections. This is the line that goes from 6D to E1 on the trainer.

(14) Turn regulator R-3 clockwise until gage P-3 shows 80 psig.

(15) Energize and deenergize the solenoid by switching switch S-2 between position 3 and OFF. Do this several times while closely observing the valve indicator. Does the valve open and close within the TO time specifications? _____

Note: You have to guess the operating time of the butterfly since the trainer timer cannot be started and stopped in only one second.

(16) Check the TO troubleshooting table for corrective action if the valve operates too slowly.

(17) Place switch S-1 to OFF, close valve V-3 and turn regulator R-3 counterclockwise until it turns freely.

(18) Disconnect all the equipment and stow in the proper places.

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(19) Disconnect the trainer power cables and clean your area. You must check with the instructor for instructions.

e. Maintenance Documentation.

(1) Get an AFTO Form 349 and AFTO Form 350 from the instructor.

(2) Use the information on the AFTO Form 350 and the note to help you make the entries on the AFTO Form 349.

Note: The mechanic who removed this unit from the aircraft had to use an AFTO Form 349 to account for the time used in removing the unit. At the same time an AFTO Form 350 is made, attached to the unit, and the unit routed to RPC. RPC sent the unit to your shop (work center J3360) for the work that would be needed to make the unit serviceable. You made a bench check of the unit to try to find why it did not work (block 14, AFTO Form 350) but, the unit checked out OK. Even though the valve checked OK and no repair was made, you must use an AFTO Form 349 to show the time you used to check the unit. This is what you are to do now. Keep in mind, the malfunction code used should show the corrective action you took.

(3) Get TO 1B-52B-06, Aircraft Work Unit Code Manual, from the TO file cabinet.

(4) On the AFTO Form 349, you must make entries in blocks 1, 2, 3, 22, 26, and 27, and in columns A, C through K, and N.

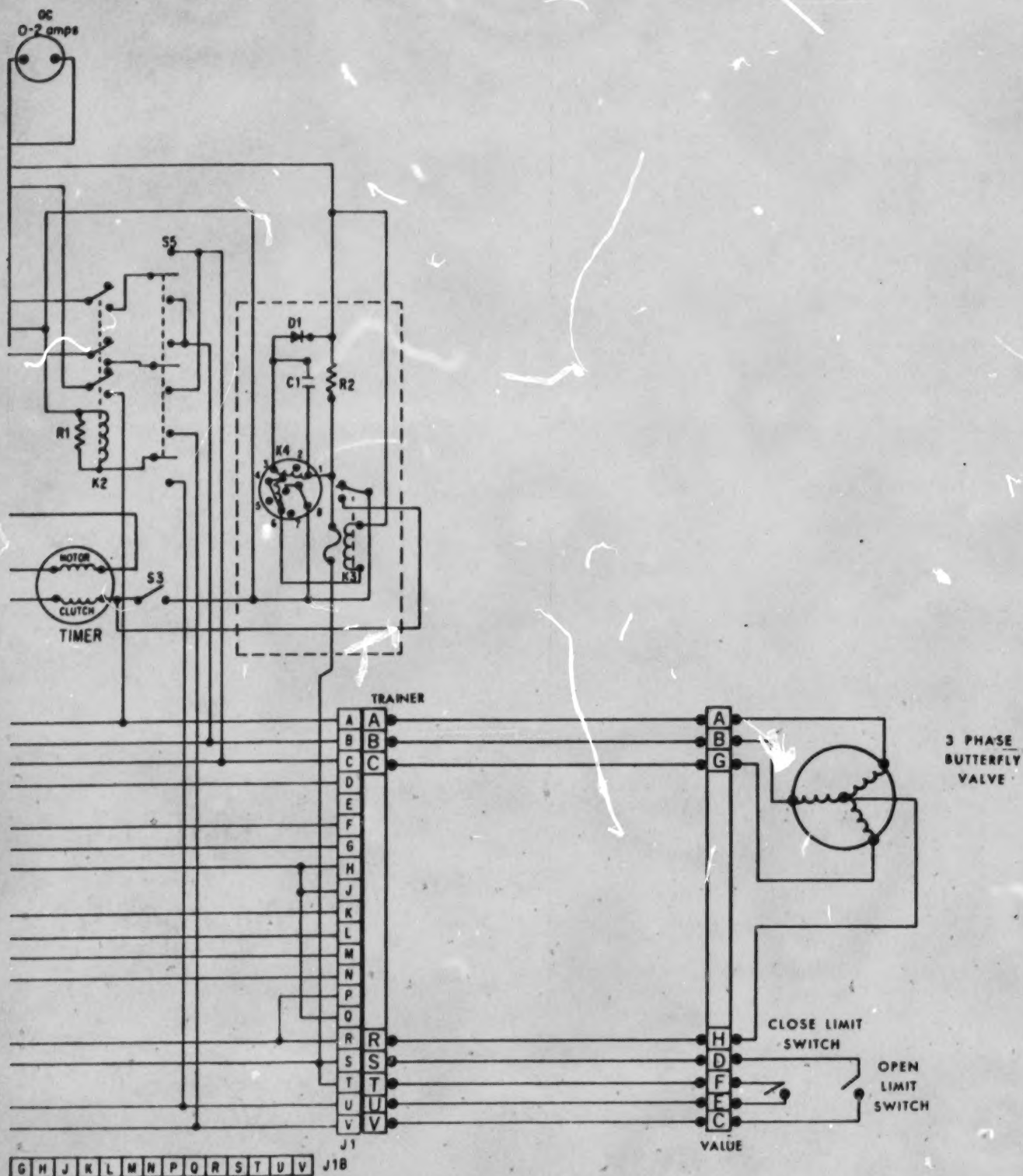
(5) In block 15 of the AFTO Form 350, you must tell what you did to the unit during the bench check.

(6) If you do not remember how to fill in the AFTO Forms 349 and 350, go back and review the Maintenance Management Text ATCPT 52-1, Volume III.

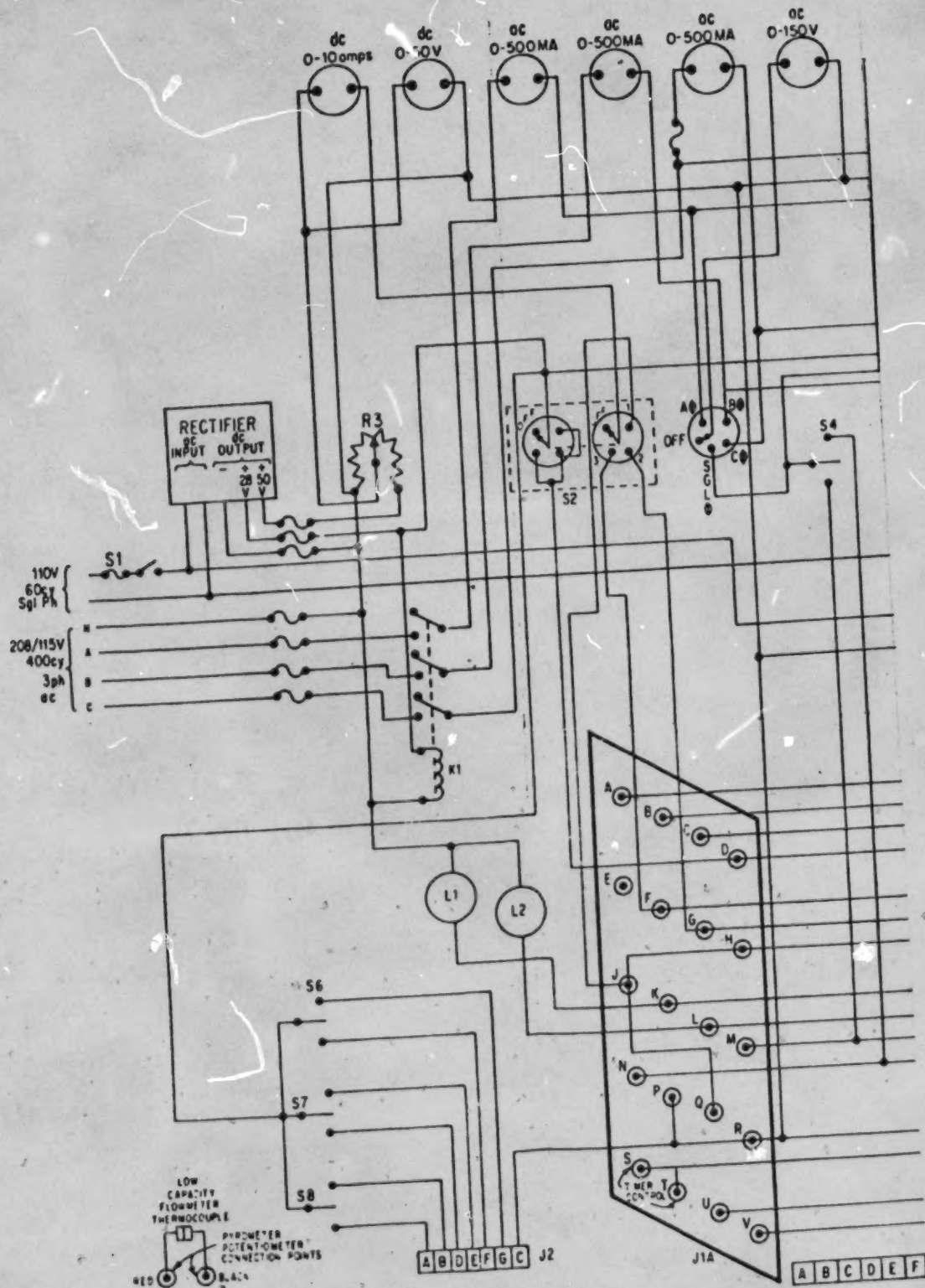
(7) Have the instructor check your forms before you go to the next project.



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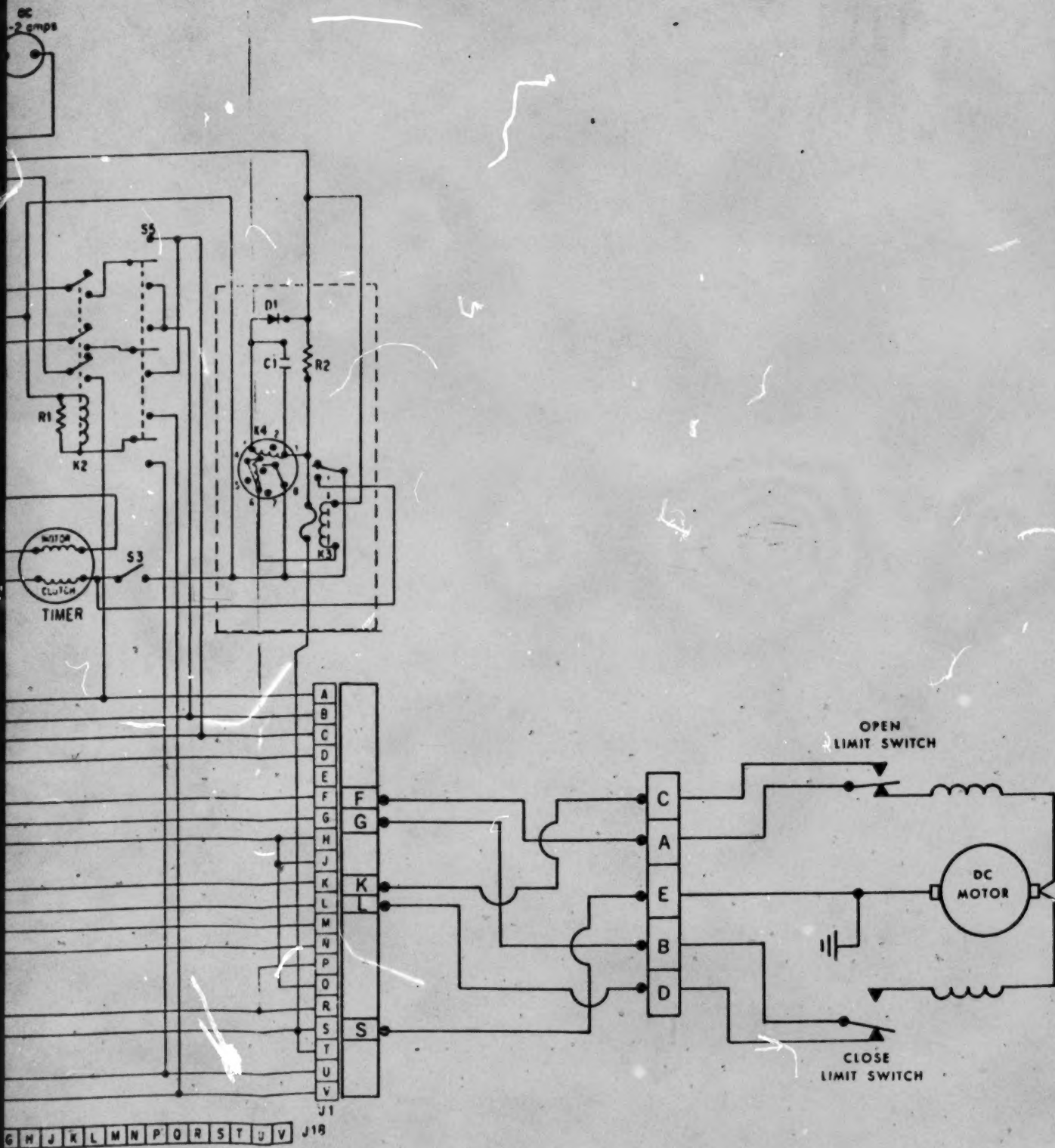


Foldout 1. Test Facility Electrical Schematic.
Section 2.

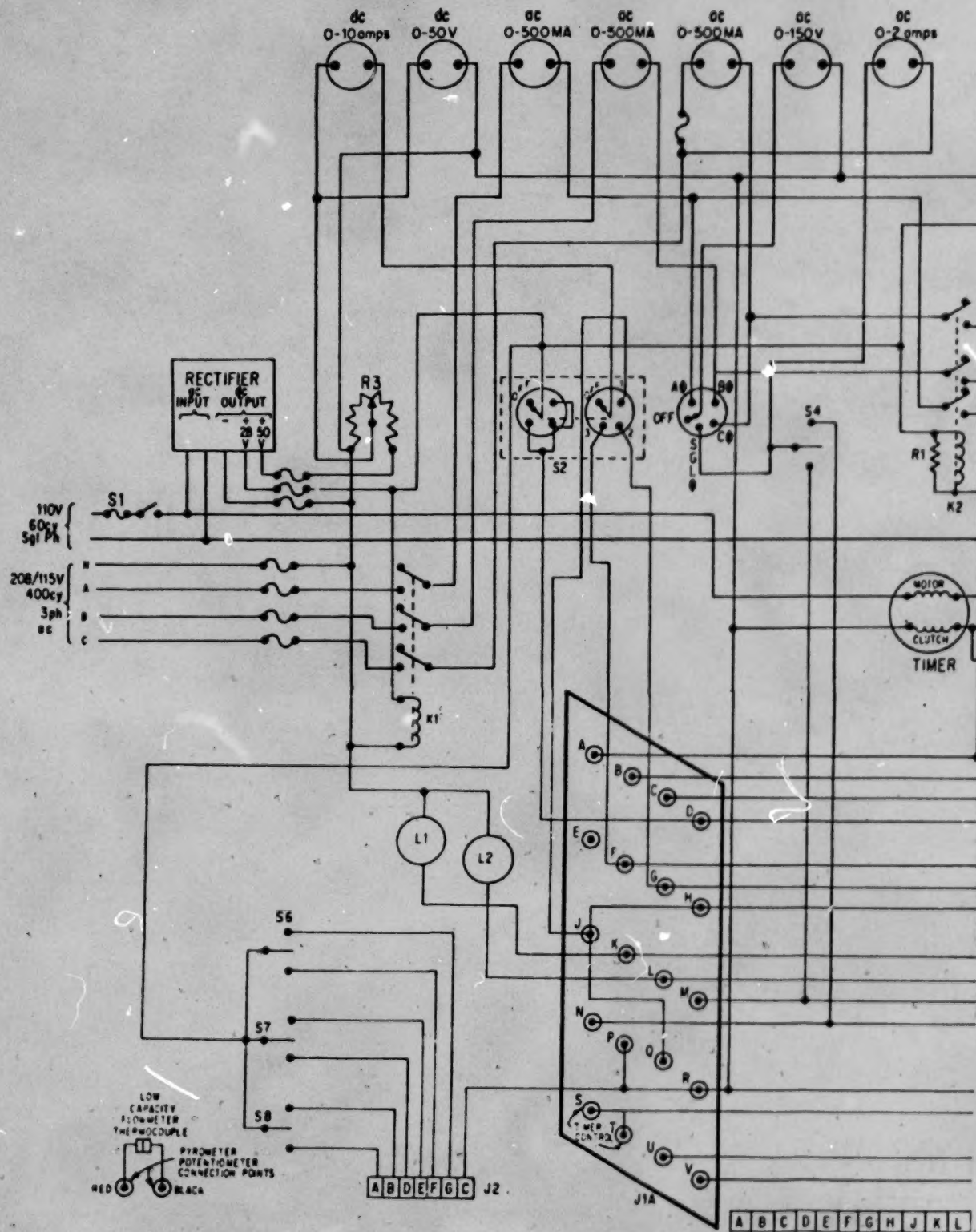


Foldout 2. Test Facility Electrical Schematic.
Section 1.

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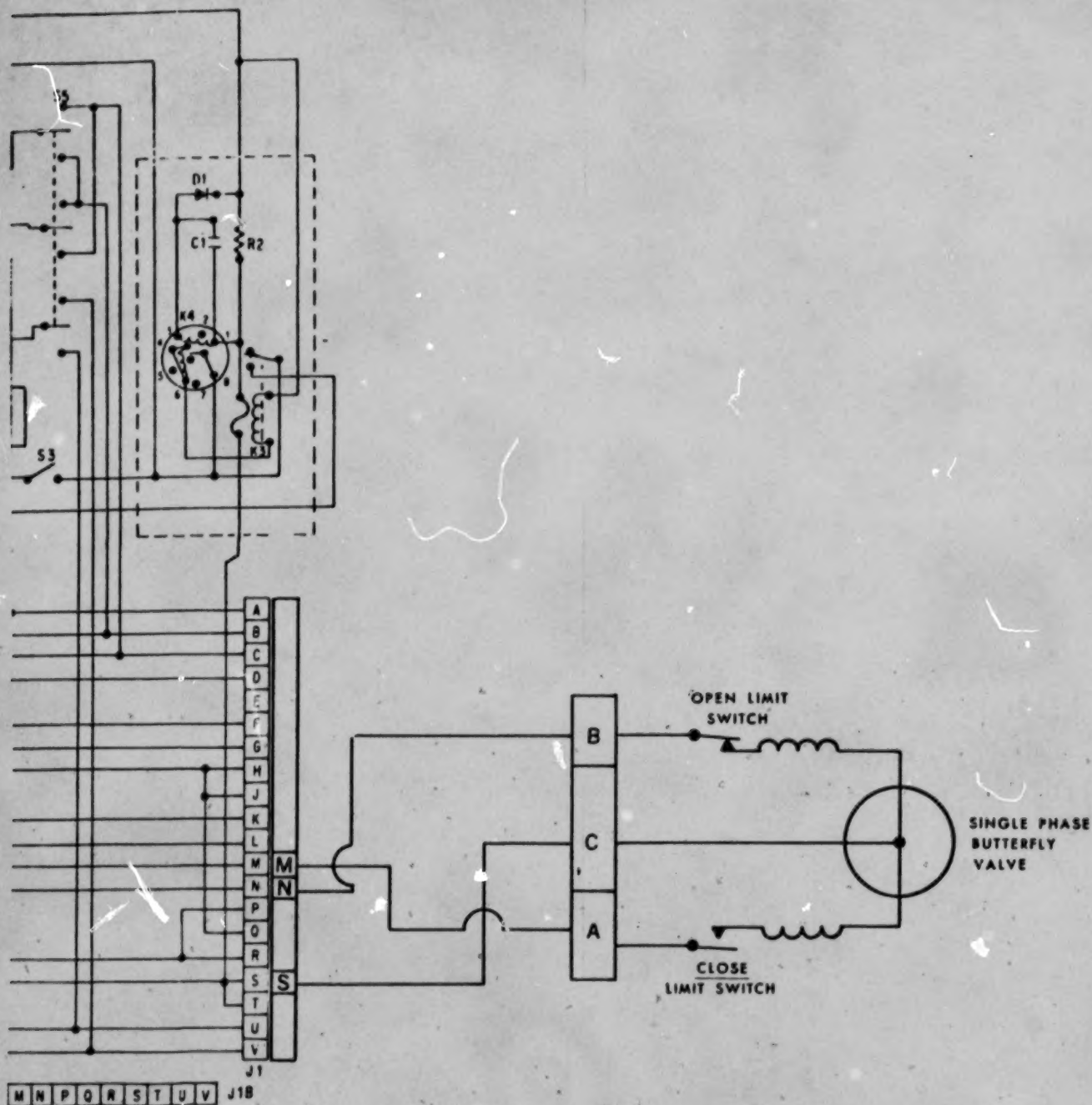


Foldout 2. Section 2.



Foldout 3. Section 1.

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Foldout 3. Test Facility Electrical Schematic.
Section 2.



Technical Training

Aircraft Environmental System Repairman

AIRFLOW CONTROL AND SHUTOFF VALVE

6 January 1976



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

2429

Environmental Pneudraulic Branch
Chanute AFB, Illinois

3ABR42231-WB-312A

AIRFLOW CONTROL AND SHUTOFF VALVE

OBJECTIVES

Upon completion of this workbook, you will be able to:

1. Inspect, operate, and calibrate the airflow control and shutoff valve.
2. Identify parts of the valve.
3. Document maintenance performed using an AFTO Form 349 and TO 1C-130A-06, Code Manual.
4. Use information from TO 15A2-2-20-193 to inspect the valve.

Standard of Performance:

You will be evaluated by an instructor using a criterion referenced test and observing your performance. You must complete this project with 70% accuracy.

EQUIPMENT

	Basis of Issue
Airflow Control and Shutoff Valve	1/student
Electrical Pneumatic Trainer (3038)	1/4 students
4" Screwdriver	1/student
5" Screwdriver	1/student
1/2" X 3/8" Open End Wrench	1/student
TO 1C-130A-06	1/student
TO 15A2-2-20-193	1/student
AFTO Form 349	1/student

PROCEDURE

By following the step by step instructions found in this text, you should have very little difficulty in the calibration and adjustment of the airflow control and shutoff valve. If you should have a problem with the valve and/or the trainer, check with your instructor. Failure to do so may cause damage to the equipment in use.

AT THIS POINT MAKE SURE THAT YOU HAVE REMOVED ALL YOUR JEWELRY.

Supersedes 3ABR42231-WB-312A, 12 August 1974, which may be used until existing stocks are exhausted.

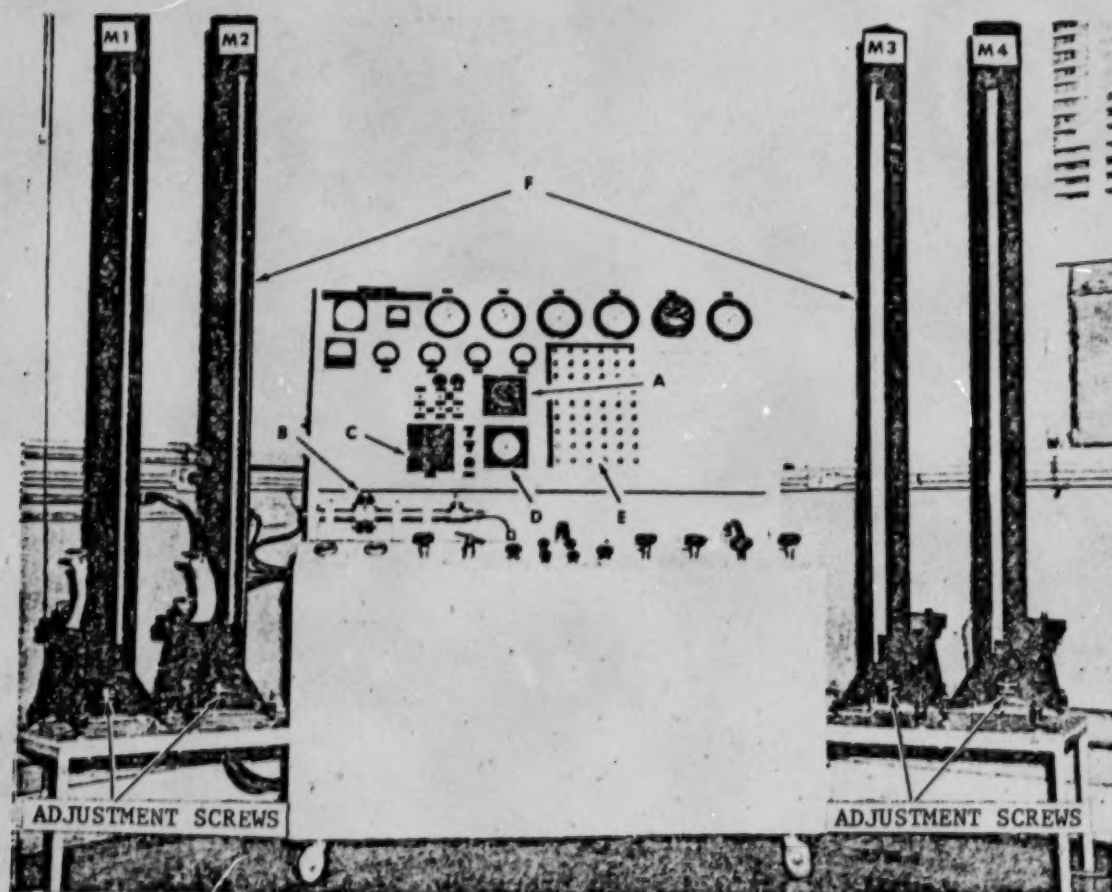
OPR: TAS

DISTRIBUTION: X

TAS - 15C; TTVGC - 1

ELECTRIC PNEUMATIC TESTER TRAINER

1. Use figure 1 to familiarize yourself with the trainer by locating the listed parts. You will be using the trainer to do the bench check operations that are required to maintain the airflow control and shutoff valve.



- | | |
|-------------------------------------|-----------------------------|
| A. Voltage Adjustment Potentiometer | D. Precision Timer |
| B. Low Capacity Flowmeter | E. Pneumatic Patching Panel |
| C. Electrical Patching Panel | F. Manometers |

Figure 1. Trainer No. 3038 - Electric Pneumatic Tester.

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- a. Voltage adjustment potentiometer (A). This is used to adjust the DC voltage on the trainer.
- b. Low capacity orifice flowmeter (B). An orifice is put in this portion of the tester so that a differential pressure may be kept at the manometers.
- c. Electrical patching panel (C). Electrical wires will be hooked from this panel to the valve under test.
- d. Precision timer (D). Gives the cycling time of the part under test. Press down on the black lever to reset before each test.
- e. Pneumatic patching panel (E). Hoses will be hooked from this panel to the valve under test.
- f. Manometers (F). These are pressure measuring devices.

AIRFLOW CONTROL AND SHUTOFF VALVE

1. Open foldout 1 at the back of the workbook. You will need to look at figure 7A as you make each check on the valve.
2. Go to locker 2 and get one airflow control and shutoff valve, part number 106616.
3. Set the valve on the trainer so the large end of the venturi is to your right, and the valve position indicator is facing you. Your view of the valve should match the view in figure 7A.
4. Use figure 7A to find each part on the valve. As you find each part put a checkmark in the blank.

1. _____ Adjustment screw "A".
2. _____ Test port "A".
3. _____ Adjustment screw "B".
4. _____ Adjustment screw "E".
5. _____ Position indicator.
6. _____ Venturi.
7. _____ Test port "B".
8. _____ Altitude sensing port.

INSPECTION REQUIREMENTS

1. Turn to the "Overhaul Instructions for the Airflow Control and Shutoff Valve, Part Number (P/N) 106616" section in the TO. The TO is in the limited TO file.

- a. The TO number is _____.
- b. The basic date of this TO is _____.
- c. The change date of this TO is _____.

2. From the information provided in TO 15A2-2-20-193 write down the inspection requirements for the airflow control and shutoff valve.

- a. Inspect all parts for evidence of _____.
- b. Inspect all metering orifices and internal air passages for _____.
- c. Inspect all _____ and _____ parts for _____.
- d. Inspect the parts listed in figure 2-5 of the TO by following the requirements listed opposite each part. All parts that do not strictly meet the requirements shall be repaired or replaced.

Correct Responses: 1a. 15A2-2-20-193 1b. 1 May 1963 1c. 15 Nov 1969

2a. corrosion, wear, or other damage

2b. presence of foreign material

2c. serrated threaded any evidence of damage

ALTITUDE COMPENSATOR BELLOWS PRESET ADJUSTMENT

1. You are now ready to start calibrating the airflow control and shutoff valve. Carefully follow each step of the calibration process. If you have any difficulty get the instructor. The first adjustment is the altitude compensator bellows preset adjustment.

2. Look at figure 7A and find adjustment screw "B". By turning adjustment screw "B" you are adjusting the position of the bellows (schematic diagram, foldout 1) in the altitude compensator. The altitude compensator is an aneroid controlled metering valve. The job of the compensator is to open the valve butterfly to let more airflow through the valve as the aircraft altitude increases. The compensator is made of a bellows, spring, and an altitude compensation adjustment screw "B".

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3. Loosen the locknut that holds adjustment screw "B" in place. Turn adjusting screw "B" clockwise () until it bottoms (stops turning). When it hits bottom, DO NOT FORCE IT ANY TIGHTER

4. Turn adjusting screw "B" exactly 3 1/2 turns counterclockwise (). Tighten the locknut. Be sure that you do not move adjustment screw "B". This adjustment presets the altitude compensator bellows.

AIR PRESSURE REGULATOR CALIBRATION

1. You will now set the air pressure regulator section of the airflow control and shutoff valve. Look at figure 7A and find adjustment screw "A". The air pressure regulator reduces air pressure in the control air system of the airflow control and shutoff valve (schematic diagram, figure 7B). The air pressure regulator is a relief valve. Operation of the regulator is controlled by a spring loaded diaphragm.

2. The electrical wires and pneumatic hoses used for connecting the valve to the trainer are in the bottom of the trainer.

3. Using the electrical wires, connect the valve cannon plug to the trainer electrical patching panel J1A (figure 1) as listed. As you do each of the steps place a checkmark in the blank.

- a. ☐ F on the trainer to A on the valve cannon plug.
- b. ☐ G on the trainer to B on the valve cannon plug.
- c. ☐ R on the trainer to C on the valve cannon plug.
- d. ☐ Turn valve V3 on the trainer clockwise to the OFF position.

4. The electrical wires will stay connected throughout the entire bench check.

5. Look at figure 2 when connecting the pneumatic hoses to the trainer pneumatic patching panel (figure 1) and to the valves. The hoses are shown by heavy black lines.

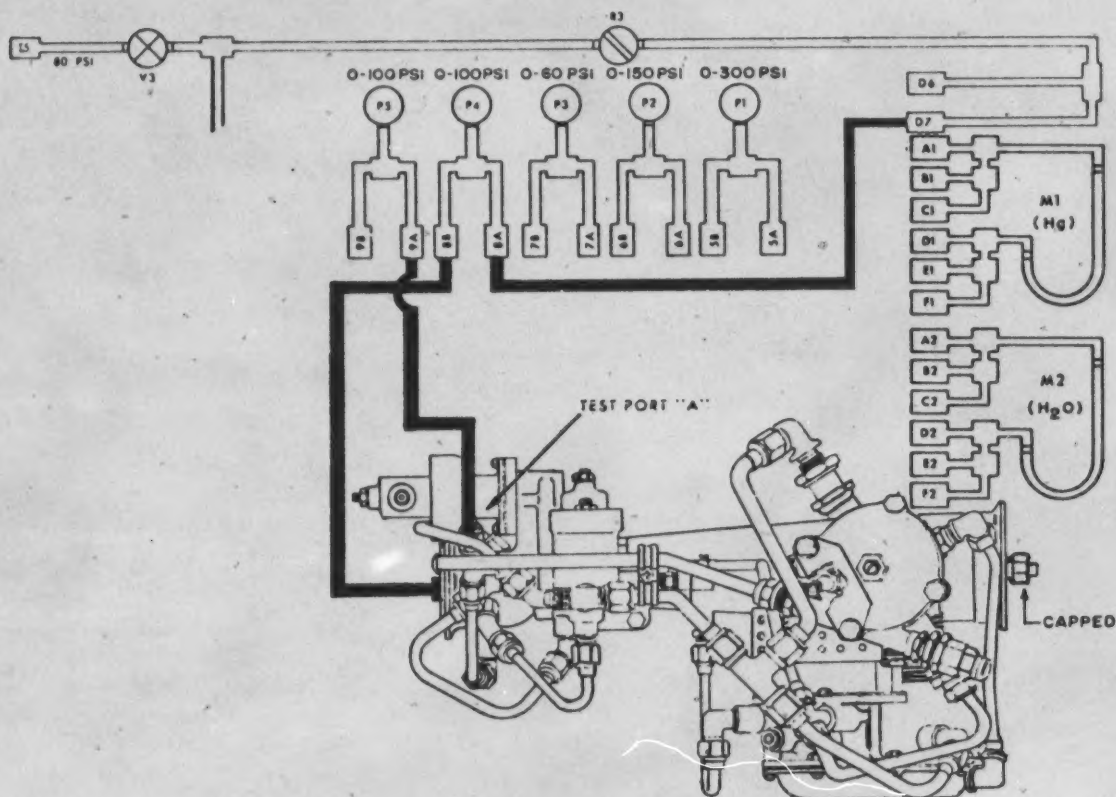


Figure 2.

- a. _____ D7 to 8A.
- b. _____ 8B to the inlet side of the valve.
- c. _____ Test port A to 9A.
- d. _____ Take the cap from the altitude sensing port (refer to figure 7A).
- e. _____ HAVE THE INSTRUCTOR CHECK YOUR CONNECTIONS.
- f. _____ Plug the 3 trainer power cords in the recepticals on the wall behind the trainer.
- g. _____ Place switch S-1 on the trainer to the ON position.
- h. _____ Place switch S-2 to the 3 position. This puts 28V DC to solenoid A.

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- i. _____ Turn V3 counterclockwise until it is full open.
 - j. _____ Turn regulator R3 clockwise until gage P-4 reads 15 PSIG.
 - k. _____ Loosen the locknut on adjustment screw A and adjust the screw until 12 PSIG shows on gage P-5. Tighten the locknut. Be careful not to move adjusting screw A. Adjustment screw A sets the air pressure regulator. We now have 12 PSI in the valve control air system.
1. _____ Turn R3 counterclockwise until 10 PSIG is read on gage P-4.

THRUST TEST

1. The thrust test is done to see whether or not the butterfly is moving to the full closed position. Do these steps to make the thrust test.

- a. _____ Check the valve position indicator. It should read CLOSED.
- b. _____ Turn switch S-2 to 1 position. This deenergizes solenoid A.
- c. _____ Check the valve position indicator. It should read OPEN.
- d. _____ Turn switch S-2 to 3 position. This energizes solenoid A.
- e. _____ Check the valve position indicator. It should read CLOSED.
- f. _____ IF THE VALVE INDICATOR DOES NOT READ "OPEN" OR "CLOSED", GET THE INSTRUCTOR.

2. The valve should have opened and closed with a minimum pressure of 10 PSI. If not, adjustment to screw "E" would be made (figure 7A).

- a. _____ Turn regulator R3 counterclockwise until gage P-4 reads 0 PSIG.
- b. _____ Remove all the pneumatic hoses.
- c. _____ Place the cap on test port A.
- d. _____ DO NOT REMOVE THE ELECTRICAL WIRES.

PORT LEAKAGE CHECK

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1. In the next calibration step, you will check for port leakage. Port leakage is leakage past the valve butterfly with the valve in the CLOSED position. Figure 3 is an illustration of port leakage.

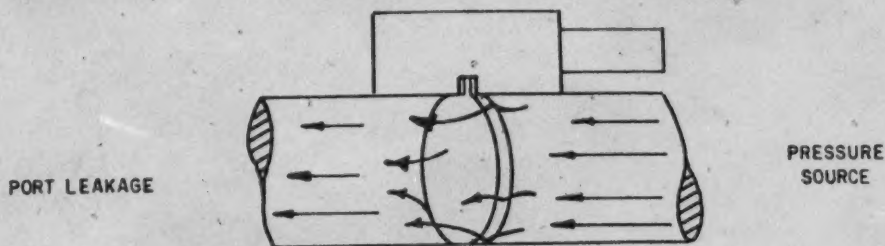


Figure 3.

2. Connect the pneumatic hoses, shown in figure 4 by the heavy black lines, to the trainer pneumatic patching panel and the valve.

- a. _____ 7D to 8A.
- b. _____ 8B to the valve inlet.
- c. _____ TP2 to the valve outlet.
- d. _____ 6F to A2.
- e. _____ 7F to E1.
- f. _____ F1 to F2.
- g. _____ Place the M-1 manometer on the inches of mercury (Hg) scale. This scale starts at 28 inches.
- h. _____ Set the top of the Hg bubble to 30 inches.
- i. _____ Place the M-2 manometer on the inches of water (H_2O) scale so that the bottom of the bubble is on zero.
- j. _____ Take off the steel cap from the 1 1/4 inch pipe at the left side of the trainer. This opens the outflow section of the .150 orifice.

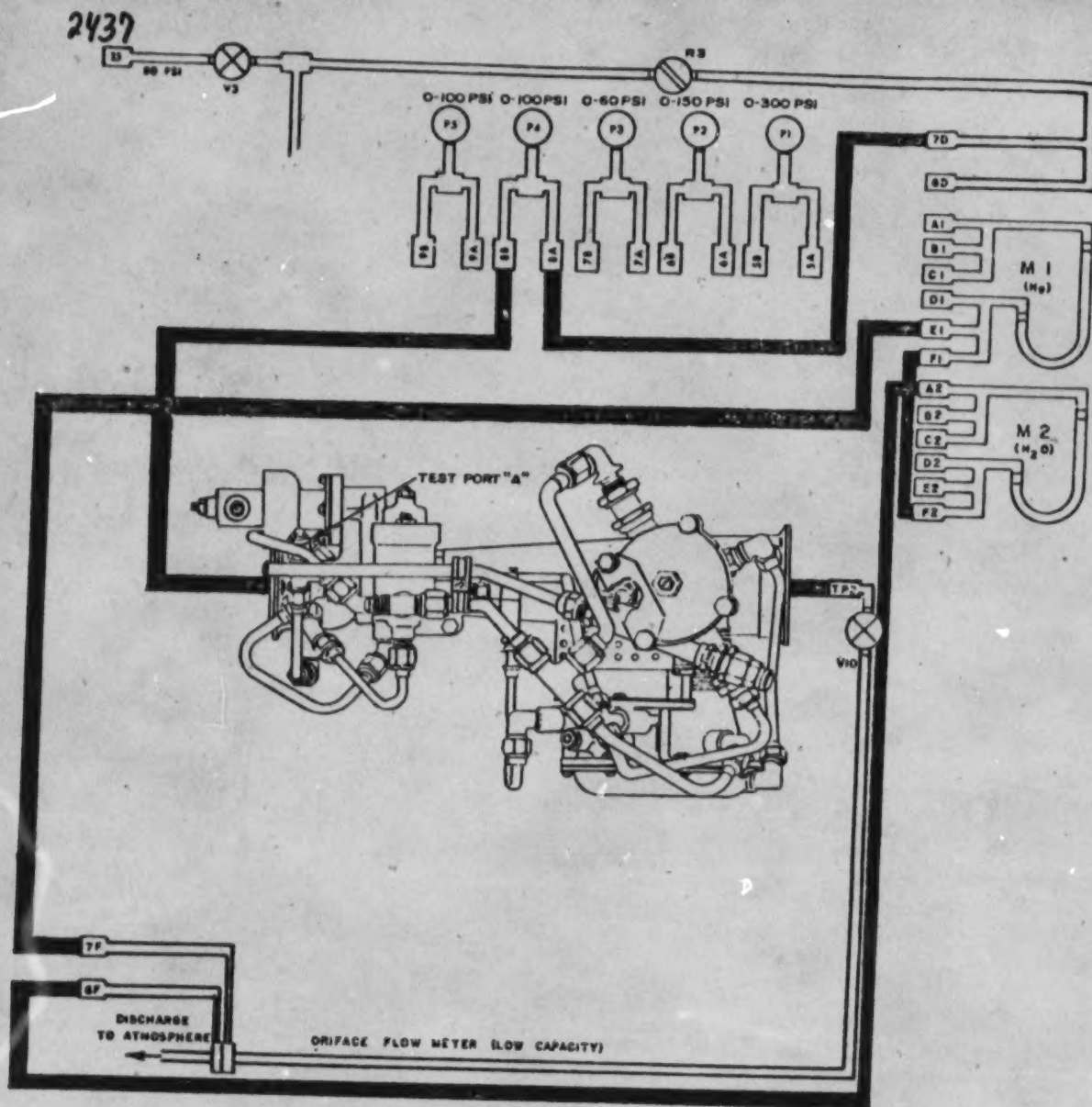


Figure 4.

k. _____ If you have followed the instructions carefully up to now, the position indicator on the valve should show at the full CLOSED point.

l. _____ Check the position of switch S-2. It must be in position 3.

m. _____ Slowly turn valve V10 to the full open position.

n. _____ Slowly turn valve V3 to the full open position.

o. _____ Turn R-3 clockwise until 45 PSIG is read on pressure gage P-4. DO NOT ALLOW THE WATER in manometer M-2 to rise above 55 inches. This is to keep you from accidentally pushing the water out the top of the manometer.

3. What is the reading on the M-1 manometer? _____

4. What is the reading on the M-2 manometer? _____

a. _____ Turn R-3 counterclockwise until 0 PSIG is read on gage P-4.

5. The next step is to see if the leakage of your valve is within normal limits. The amount of air passing the closed butterfly is measured in pounds per minute (PPM). The formula used to determine the amount of leakage is:

$$\Sigma \Delta P = \frac{17.35 \times P_1}{T_1 + 460} \Delta P$$

P_1 is the M-1 manometer reading.

P is the M-2 manometer reading.

T_1 is the temperature of the air.

6. Read the lab thermometer. The temperature is _____.

7. After you have determined $\Sigma \Delta P$, use the conversion chart (figure 5) to convert $\Sigma \Delta P$ to airflow in pounds per minute (PPM).

8. Your valve is leaking _____ PPM.

9. Turn to the "Test and Calibration Instructions" section in the TO. Find the allowable port leakage. Leakage must not be more than _____ PPM.

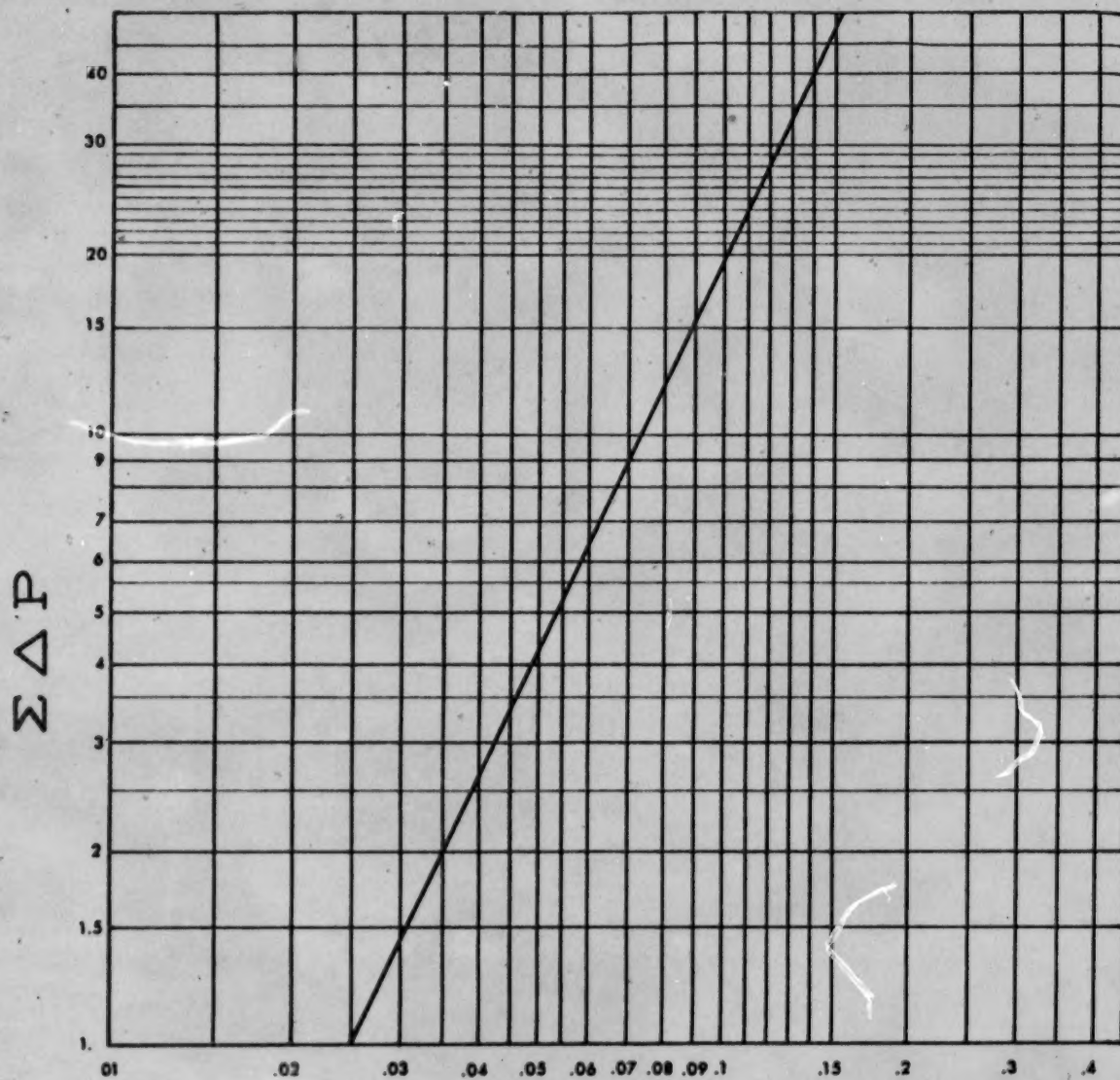
10. Is your valve leaking too much? _____. If the valve leaks too much, tell the instructor.

a. _____ Remove all pneumatic hoses.

b. _____ DO NOT REMOVE THE ELECTRICAL WIRES.

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FOR AIRFLOWS THROUGH A 0.150 INCH ORIFICE IN A 1.0 INCH I.D METER SECTION



AIR-FLOW IN POUNDS PER MINUTE

Figure 5.

BELLOWS PRESSURE CHECK

1. The last adjustment you will make on the valve is the bellows pressure check. It is set to keep a proper flow of air through the valve from the ground up to the operating altitude. Look at figure 6 to find test port B and adjusting screw B. Connect the pneumatic hoses shown by the heavy black lines.

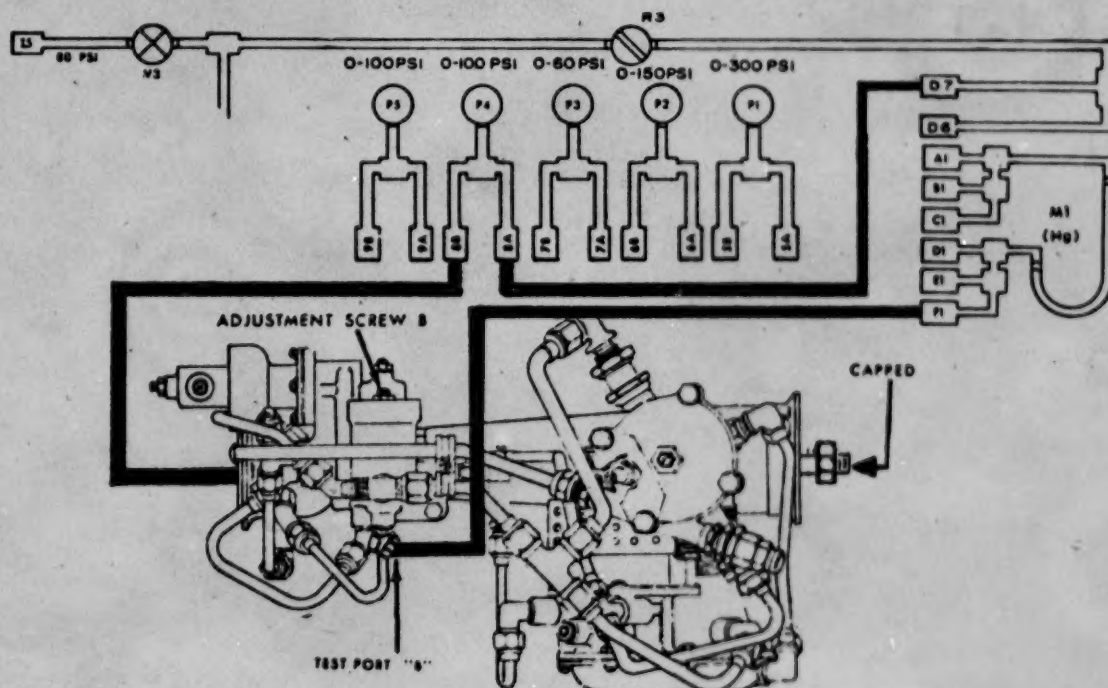


Figure 6.

- a. _____ D7 to 8A.
- b. _____ 8B to the inlet of the valve.
- c. _____ P1 to test port B of the valve.
- d. _____ Open valve V-3.
- e. _____ Turn regulator R-3 until 50 PSIG is read on gage P-4.
- f. _____ Loosen the lock nut on adjustment screw "B" and turn the screw until manometer M-1 reads 33 Hg. Tighten the locknut. Be careful not to move the adjustment screw.
- g. _____ Turn regulator R-3 until 0 PSIG is read on gage P-4.

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2. Shutdown procedures.

- a. _____ Remove all pneumatic hoses and plug them. Place them neatly in the bottom of the trainer.
- b. _____ Remove all electrical wires and place them neatly in the bottom of the trainer.
- c. _____ Put the steel cap on the 1 1/4 inch pipe at the left side of the trainer.
- d. _____ Unplug the trainer and lay the wires across the work bench part of the trainer.
- e. _____ Cap all trainer outlets.
- f. _____ Replace the caps on the valve.
- g. _____ Tape the cannon plug on the valve and return the valve to locker #2.
- h. _____ HAVE THE INSTRUCTOR INPSECT YOUR TRAINER.

MAINTENANCE DOCUMENTATION USING AFTO FORM 349

Now that you are done bench checking the airflow control and shutoff valve you have to do the paper work. Get an AFTO Form 349 from the instructor and TO 1C-130A-06 Code Manual from the limited TO file. Using the information below and in the code manual, complete the AFTO Form 349 for bench checking the airflow control and shutoff valve. When you have completed the form have the instructor check it.

Job Control Number ----- 1180027
 Work Center ----- A92EJ
 ID Number ----- CA3476
 Priority ----- 3
 Location ----- Shop
 Type Maintenance ----- Unscheduled
 When Discovered ----- Minor Inspection

Note: The blocks to be filled are: 1, 2, 3, 7, 9, A, C, K, N, 26, and 27.

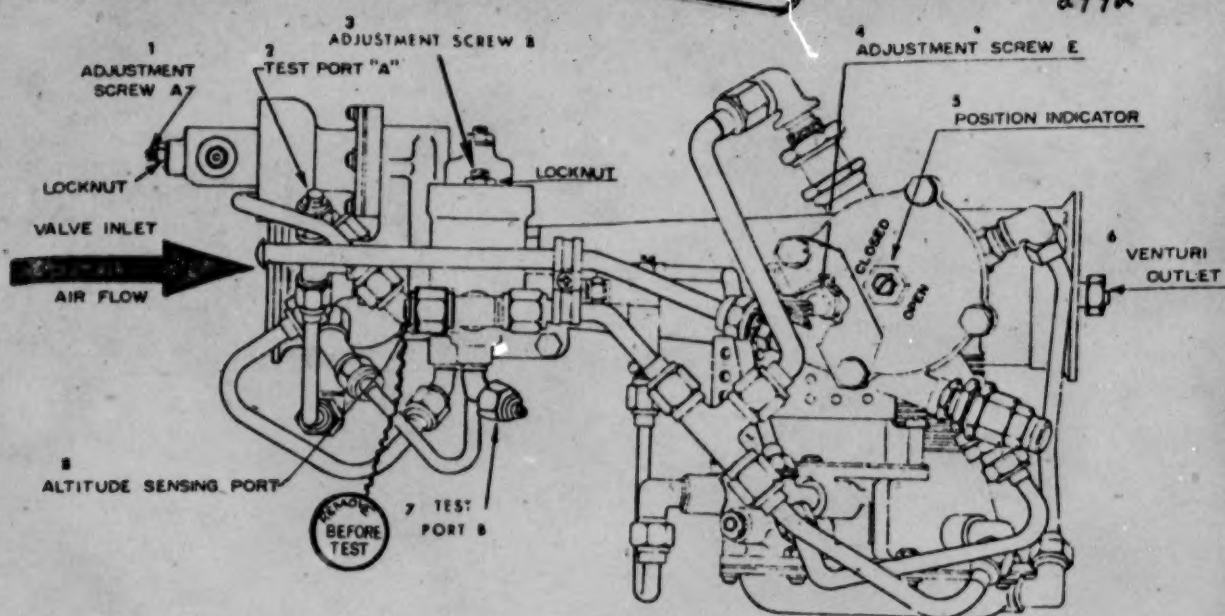


Figure 7A
AIRFLOW CONTROL AND SHUTOFF VALVE

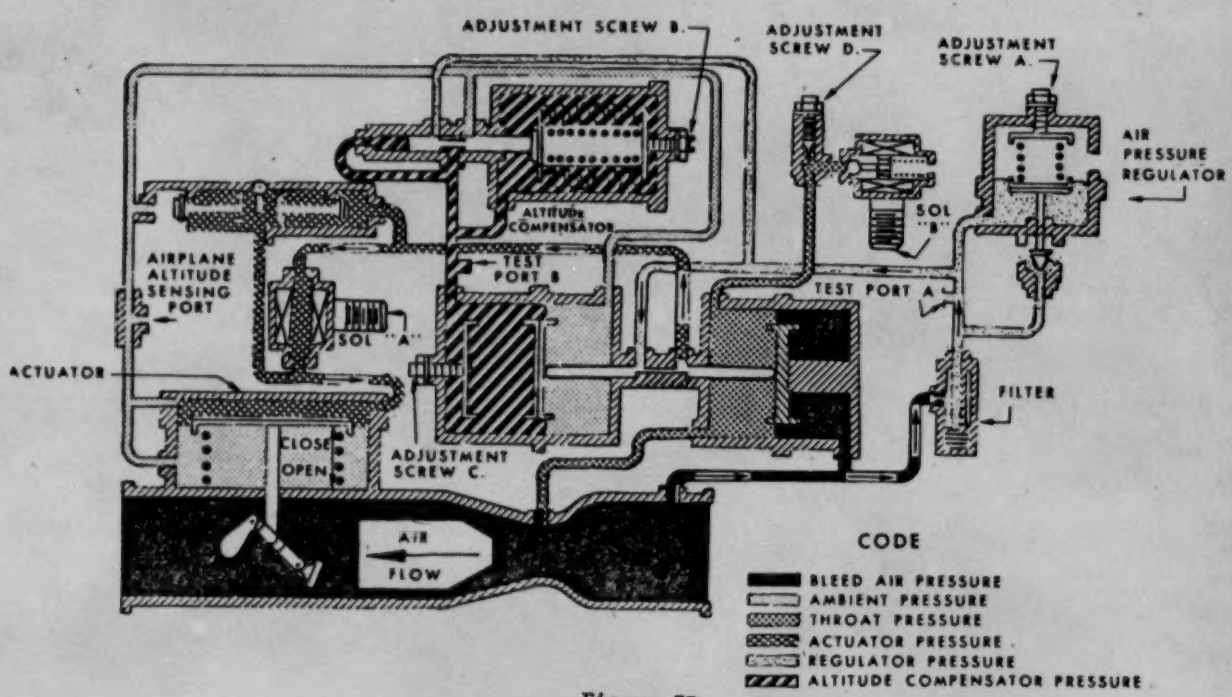


Figure 7B
AIRFLOW CONTROL AND SHUTOFF VALVE SCHEMATIC DIAGRAM

AFTO FORM 350 FEB. 1977
PREVIOUS EDITION WILL BE USED

BUDGET BUREAU
NO. 21-40227



REPAIRABLE ITEM PROCESSING TAG

1. JOB CONTROL NO.	2. ID / SERIAL NO.	3. TM	3A. BRD	4. WORK DATE
5. HOW MAL	6. MDS	7. WORK UNIT CODE	8. ITEM OPER. TIME	9. QTY.
10. FSC	11. PART NUMBER			
12. SERIAL NUMBER	13. SUPPLY DOCUMENT NUMBER			
14. DISCREPANCY				
15. SNOP USE ONLY				
16A. CMO / ACT ID				
TAG NO. 259169		AFTO 350 PT. 1		
16. SUPPLY DOCUMENT NUMBER				
17. NOMENCLATURE				
18. PART NUMBER				
19. NSN				
20. ACTION TAKEN	21. QTY.	22. RPC. USE ONLY		
TAG NO. 259169		AFTO 350 PT. 2		

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WARNING

Unauthorized persons removing, defacing, or destroying this tag (or label) may be



subject to a fine of not more than \$1,000 or imprisonment for not more than one year or both.
(18 USC 1 361)

REPAIR CYCLE DATA

23. NSN	24. SRAN CODE
25. TRANSPORTATION CONTROL NUMBER	
STATUS CHANGED TO	
26. SERVICEABLE	
27. CONDEMNED	
28. SUPPLY INSPECTOR'S STAMP	
29. BASE REPAIR CYCLE DATA	MO. DAY YR. TIME
DATE REMOVED	REC'D BY RPC
TO:	
TO:	
TO:	
TO:	
TO:	
TO:	
DATE COMPLETED	

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PROGRAMMED TEXT

3ABR42331-PT-313

Technical Training

Aircraft Environmental Systems Mechanic

PRINCIPLES OF ANTI-G SYSTEM

12 November 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42231 Instructional System. The material contained herein has been validated using thirty-one 42010 students enrolled in the 3ABR42231 course. Ninety-eight percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 56 minutes to complete the text.

OBJECTIVES

After completion of this text, you will be able to answer discrimination questions with a minimum of 70% accuracy, on typical anti-G valve system, that relate to:

1. Operation of an anti-G valve.
2. Purpose of an anti-G valve.
3. Major components of an anti-G valve.

INSTRUCTIONS

This text presents information in small steps called "frames." After each step you are asked to select a correct statement. DO NOT MARK IN THIS TEXT. The correct answers may be found on the top of the next even numbered page. If your answer is correct, go to the next frame; if you are wrong, read the frame again. As you read the text, the anti-G valves will be available for you to see and inspect.

Supersedes 3ABR42231-PT-313, 24 April 1973.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 2

Because of the speed of jet aircraft, great forces and strains are experienced by the pilot. On level flights there is no limit to the speed that pilots can endure. But in loops, turns, and climbs, forces on the pilot's body are more than he can endure. Centrifugal force (G) is that force which pulls outward from the center of rotation. This force is "G" force. The unit measure is called a "G." Sitting in an aircraft on the flight line, your weight on the seat is the force of gravity. This force is equal to 1 G, or equal to the weight of your body. If you sat on a scale during level flight, you would notice that your weight would be normal. But during maneuvers, your weight would become more (indicating a positive "G") or less (indicating a negative "G"). This would depend on the maneuver. You can see that the G force can be positive or negative. If the force acts to hold you down in the seat (figure 1) it is a positive "G." However, if the force tends to lift you from the seat, it would be a negative "G."



Figure 1. Effects of Positive G Forces.

Answer the statements as true (T) or false (F).

1. Centrifugal force pulls outward from the center of rotation.
2. A G force is a unit of measure for centrifugal force.
3. Sitting in an aircraft on the flight line, you are pulled down into the seat by gravity. This is equal to 0 "Gs."
4. During negative "G" forces your weight increases.
5. "G" forces can be either negative or positive.

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CORRECT RESPONSES TO FRAME 1: 1. T 2. F 3. F 4. F
5. T

Frame 2

Aircraft environmental systems personnel have the responsibility for the maintenance of the anti-G suit system. The system consists of air lines from the air source to the anti-G suit valve. This valve is shown in figure 2. The air lines then go from the valve to the anti-G suit. The air lines are not normally a source of trouble. Your main job will be checking the anti-G suit valve for proper operation. There are four tests which you will perform: (1) first-stage relief valve adjustment; (2) first-stage chamber pressure adjustment; (3) second-stage relief valve adjustment; (4) trip acceleration test. In order to understand the "Hows and Whys" of the tests, you must know how the valve works.

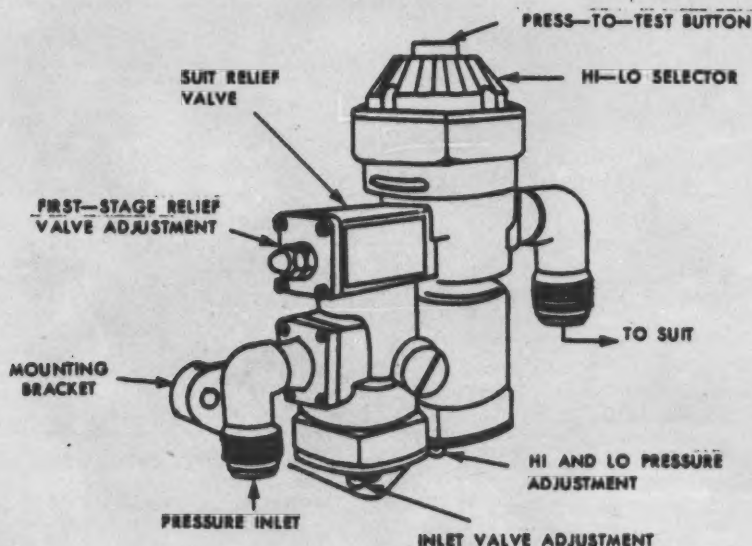


Figure 2. MD-1 Anti-G Suit Valve.

Answer the statements as true (T) or false (F).

1. Aircraft environmental systems personnel are responsible for checking and testing the anti-G suit valve.
2. There are only three tests you will perform when testing the anti-G suit valve.
3. Air lines are usually the main source of trouble.
4. Before you test the anti-G suit valve, you should know how it works.

During a positive G force, the flow of blood going to the brain is greatly reduced. Low blood pressure causes dizziness, poor eyesight, and a person may soon become unconscious. G forces will affect pilots in different ways, due to the individual's own body structure. The anti-G suit, figure 3, is made of 5 rubber bladders. When the suit is blown up, these bladders tighten around the lower parts of the body. By tightening, enough blood is kept in the brain during a positive G force. The bladders tighten only during positive G forces caused by the aircraft maneuvers. The suit air pressure increases as the positive G forces increase.



Figure 3. Bladder System.

Answer the statements as true (T) or false (F).

1. No effects are felt by a pilot during a positive G force.
2. During a positive G force maneuver, the blood flow to the brain increases.
3. Decreasing the blood flow to the brain causes dizziness, poor eyesight, and a pilot may soon become unconscious.
4. The anti-G suit is made of four inflatable rubber bladders.
5. The bladders tighten around the lower parts of the body.
6. The pressure decreases in the bladders as the positive G force increases.

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CORRECT RESPONSES TO FRAME 2: 1. T 2. F 3. F 4. T

CORRECT RESPONSES TO FRAME 3: 1. F 2. F 3. T 4. F
5. T 6. T

Frame 4

Now let us see how the anti-G suit valve inflates the anti-G suit. Engine bleed air is the source of air used to operate the anti-G suit valve and suit. Look at figure 4 at the back of the text. Follow the arrows as the valve is discussed. As you can see the valve parts are identified. We will discuss the first-stage chamber of the valve. The first-stage chamber has the following parts: air inlet valve (5), first-stage relief valve (6), inlet screen (7), pressure reducing bellows (8), and the adjustment screw (9).

Note: Both figures show the HI-LO selector in the LO position. When in the LO position, the HI weight is locked in the up position as shown so only the LO weight will move.

Answer the statements as true (T) or false (F).

1. The major parts in the first chamber of the anti-G suit valve are: the pressure reducing bellows and air inlet valve, first-stage relief valve, inlet screen, and the adjustment screw.
2. Engine bleed air is used as a source of air for the anti-G suit.

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Frame 5

Bleed air flows into the first-stage chamber through the inlet port. Air pressure in the chamber is controlled at 21 to 22 psi by the air inlet valve (5) and the pressure reducing bellows (8). When chamber pressure is less than 21 to 22 psi, the bellows moves the pivot. This moves the air inlet valve back so bleed air can enter the first-stage chamber. When air pressure in the chamber is 21 to 22 psi the bellows is compressed, and will close the air inlet valve. The adjustment screw (9) is turned right or left to increase or decrease pressure on the spring and put the bellows at the right psi setting. The inlet screen (7) keeps foreign matter out of the anti-G suit valve.

Answer the statements as true (T) or false (F).

1. The pressure reducing valve and the demand valve are both in the first-stage chamber.
2. The purpose of the pressure reducing bellows is to control air pressure in the first-stage chamber.
3. Air pressure in the first-stage chamber is held at 21 to 22 psi.
4. When the bellows expands, the air inlet valve closes.

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CORRECT RESPONSES TO FRAME 4: 1. T 2. T

CORRECT RESPONSES TO FRAME 5: 1. F 2. T 3. T 4. F

Frame 6

The first-stage relief valve (6) is located in the first-stage chamber. This serves as a safety valve should the pressure reducing bellows fail to regulate the air pressure at 21 to 22 psi. The relief valve opens when air pressure in the chamber reaches 25 to 26 psi.

Answer the statements as true (T) or false (F).

1. The first-stage chamber air pressure is 21 to 22 psi.
2. The first-stage relief valve acts as a safety valve.
3. The first-stage relief valve is set to open at 25 to 26 psi.

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The second-stage chamber controls air pressure to the anti-G suit during a positive "G" force. The second-stage chamber has these parts: press-to-test button (1), HI-LO selector (2), second-stage relief valve (3), second-stage relief valve adjustment screw (4), demand valve (13), diaphragm return spring (14), diaphragm (15), deflation valve (16), low weight (17), and high weight (18). Look at figure 4. The demand valve (13) opens and air flows from the first-stage chamber to the second-stage chamber and the anti-G suit. If pressure in the chamber is 9 to 11 psi the second-stage relief valve (3) opens to drop the pressure. Air goes through the vent in the second-stage relief valve. The relief valve is used to stop the buildup of too much pressure in the anti-G suit. It acts as a safety valve. We want just enough pressure in the suit to keep blood from being forced to the feet of the pilot. Too much pressure is as dangerous as not enough. If the suit was over inflated, it would cut off the flow of blood from the pilot's waist down to his feet. The adjustment screw (4) increases or decreases pressure on the spring to put the valve at the proper setting.

Answer the statements as true (T) or false (F).

1. The low and high weights are two parts that are located in the second-stage chamber.
2. Excessive air in the suit would have no effect on the pilot.
3. The demand valve allows air to escape into the first-stage chamber.
4. The second-stage relief valve will relieve pressure at 11 psi.
5. The setting that the second-stage relief valve relieves at depends upon the spring pressure.

CORRECT RESPONSES TO FRAME 6: 1. T 2. T 3. T

CORRECT RESPONSES TO FRAME 7: 1. T 2. F 3. F
4. T 5. T

Frame 8

Look at figure 4 as we explain the way by which the weights control air pressure to the anti-G suit. First we will explain the operation with the HI-LO selector (2) in the LO position. As positive "G" forces build up the LO weight (17), will be forced down on the diaphragm (15), and close the deflation valve (16). The deflation valve is connected to the demand valve (13), which will open. The amount the demand valve opens is determined by the strength of the "G" force acting on the LO weight. Opening the demand valve allows air to flow from the first-stage chamber, through the second-stage chamber to the suit. Keep in mind that air pressure in the second-stage chamber and suit is controlled (9 to 11 psi) by the second-stage relief valve.

When the HI-LO selector is moved to the HI position, the HI weight (18) drops on top of the LO weight. Except for the increase in weight the valve operates as discussed in the LO position.

Look at figure 5. As the "G" force decreases, the weights move up. The diaphragm return spring (14) will force the deflation valve open and releases air pressure from the suit. The demand valve will close. Pressure from the suit will be vented to the cockpit. (Note the direction of the arrows.)

Answer the statements as true (T) or false (F).

1. When a positive "G" force is applied to the weights, the weights move down.
2. The weight forces the diaphragm down and closes the deflation valve.
3. The deflation valve is connected to the demand valve by a common shaft.
4. When no "G" forces are applied, the demand valve opens.
5. When deflating, the pressure from the suit is vented to the cockpit.

Frame 9

The HI-LO selector (2) is used to select a high or low pressure setting to the suit. The pilot selects the position most comfortable for him. When the selector is in the LO range, the low weight controls air to the suit at one (1) psi for every "G" force over 1.7 "Gs."

If a pilot pulls 5 Gs in the low range, pressure to the suit would be approximately 3.3 psi. To figure this problem: Subtract 1.7 Gs from 5Gs and multiply by 1 psi. ($5G - 1.7G = 3.3G$) $3.3G \times 1 \text{ psi} = 3.3 \text{ psi}$ to the suit.

Find the psi rating for the G forces shown.

1. 3 Gs _____ to the suit.
2. 6 Gs _____ to the suit.
3. 7 Gs _____ to the suit.
4. 8 Gs _____ to the suit.

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CORRECT RESPONSES TO FRAME 8: 1. T 2. T 3. T
4. F 5. T

CORRECT RESPONSES TO FRAME 9: 1. 1.3 2. 4.3 3. 5.3 4. 6.3

Frame 10

When the HI-LO selector is in the HI position, both the high and low weight control pressure to the suit. When "G" forces act on the weight, they will control pressure to the suit at 1.5 psi for every "G" force over 1.5 "Gs."

Example: If a pilot pulls 7 Gs in the HI range, pressure to the suit would be approximately 8.25 psi. To figure the problem: Subtract 1.5 G from 7 G, this is 5.5 G; multiply 5.5 G by 1.5 psi, this will give you 8.25 psi.

Solve the following problems in the HI range for the pressure to the suit.

1. 3 G _____ to the suit.
2. 6 G _____ to the suit.
3. 2 G _____ to the suit.
4. 8 G _____ to the suit.

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The press-to-test button (1) is used to check for leaks when the pilot makes his hookup between the suit and the valve. It is also used to see if the valve is delivering pressure to his suit. When the press-to-test button is pressed, it forces the low weight down closing the deflation valve and opening the demand valve. It is also used to check the second-stage relief valve.

Answer the statements as true (T) or false (F).

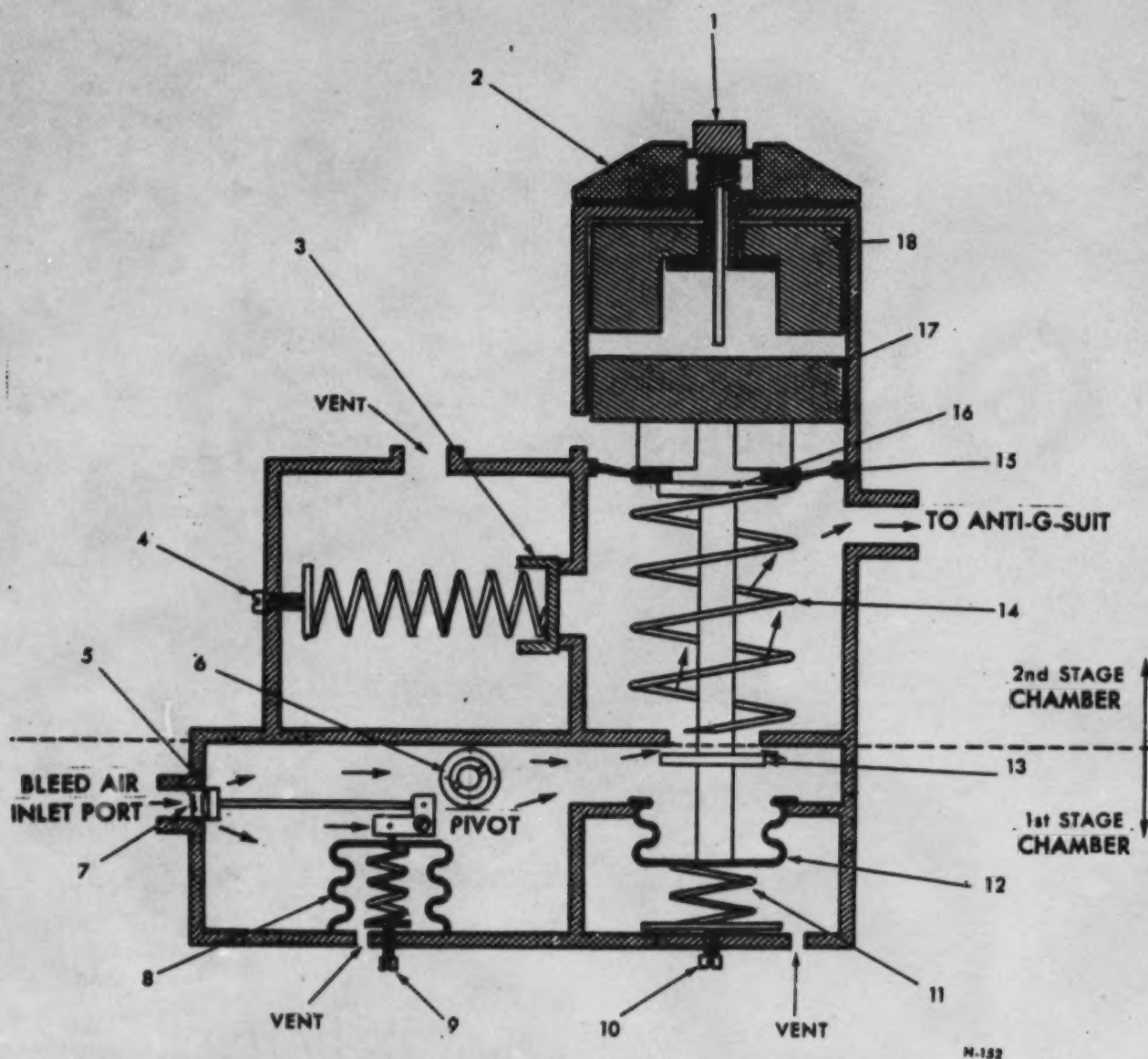
1. The press-to-test button is used to check leaks in the suit.
2. The press-to-test button actuates the low G weight.
3. It is used to check the second-stage relief valve.
4. The pilot does not use the press-to-test button.

2457

CORRECT RESPONSES TO FRAME 10: 1. 2.25 2. 6.75 3. .75 4. 9.75

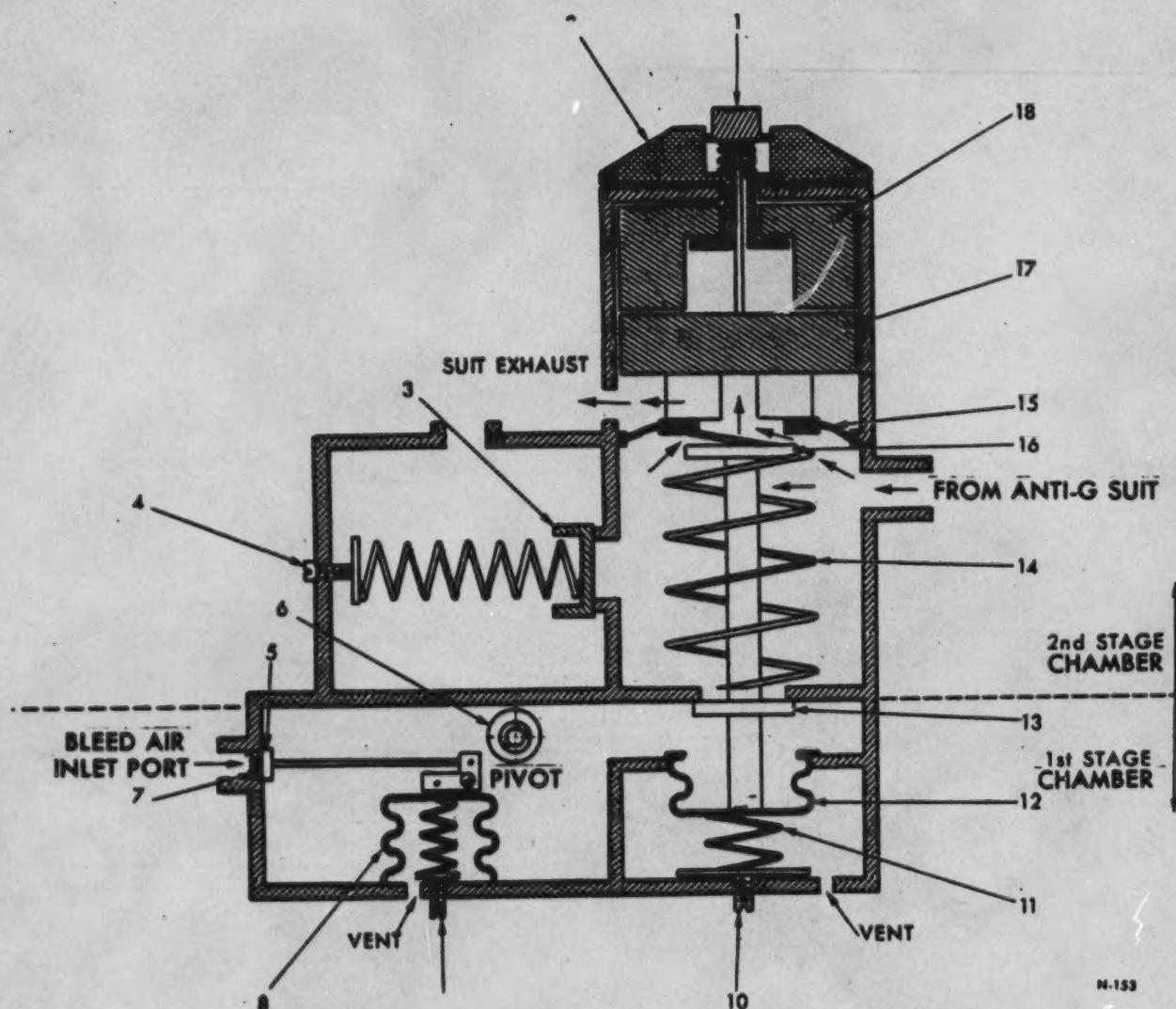
CORRECT RESPONSES TO FRAME 11: 1. T 2. T 3. T 4. F

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- | | |
|----------------------------------|-----------------------------|
| 1. Press-To-Test Button | 10. Spring Adjustment |
| 2. Hi-Lo Selector | 11. Valve Return Spring |
| 3. Second-Stage Relief Valve | 12. Valve Balancing Bellows |
| 4. Second-Stage Adjustment Screw | 13. Demand Valve |
| 5. Air Inlet Valve | 14. Diaphragm Return Spring |
| 6. First-Stage Relief Valve | 15. Diaphragm |
| 7. Inlet Screen | 16. Deflation Valve |
| 8. Pressure Reducing Bellows | 17. Low Weight |
| 9. Pressure Regulator Adjustment | 18. High Weight |

Figure 4. M-8 Anti-G Suit Valve Inflating Suit.



- | | |
|----------------------------------|-----------------------------|
| 1. Press-To-Test Button | 10. Spring Adjustment |
| 2. Hi-Lo Selector | 11. Valve Return Spring |
| 3. Second-Stage Relief Valve | 12. Valve Balancing Bellows |
| 4. Second-Stage Adjustment Screw | 13. Demand Valve |
| 5. Air Inlet Valve | 14. Diaphragm Return Spring |
| 6. First-Stage Relief Valve | 15. Diaphragm |
| 7. Inlet Screen | 16. Deflation Valve |
| 8. Pressure Reducing Bellows | 17. Low Weight |
| 9. Pressure Regulator Adjustment | 18. High Weight |

Figure 5. M-8 Anti-G Suit Valve Inflating Suit.

RESPONSE SHEET 3ABR42231-PT-313

PRINCIPLES OF ANTI-G SYSTEM

Frame 1

1. ____ 4. ____
 2. ____ 5. ____
 3. ____

Frame 2

1. ____ 3. ____
 2. ____ 4. ____

Frame 3

1. ____ 4. ____
 2. ____ 5. ____
 3. ____ 6. ____

Frame 4

1. ____ 2. ____

Frame 5

1. ____ 3. ____
 2. ____ 4. ____

Frame 6

1. ____ 3. ____
 2. ____

Frame 7

1. ____ 4. ____
 2. ____ 5. ____
 3. ____

Frame 8

1. ____ 4. ____
 2. ____ 5. ____
 3. ____

Frame 9

1. ____
 2. ____
 3. ____
 4. ____

Frame 10

1. ____
 2. ____
 3. ____
 4. ____

Frame 11

1. ____ 3. ____
 2. ____ 4. ____

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RESPONSE SHEET 3ABR42231-PT-313

PRINCIPLES OF ANTI-G SYSTEM

<u>Frame 1</u>	<u>Frame 5</u>	<u>Frame 9</u>
1. _____ 4. _____	1. _____ 3. _____	1. _____
2. _____ 5. _____	2. _____ 4. _____	2. _____
3. _____	<u>Frame 6</u>	3. _____
<u>Frame 2</u>	1. _____ 3. _____	4. _____
1. _____ 3. _____	2. _____	<u>Frame 10</u>
2. _____ 4. _____	<u>Frame 7</u>	1. _____
<u>Frame 3</u>	1. _____ 4. _____	2. _____
1. _____ 4. _____	2. _____ 5. _____	3. _____
2. _____ 5. _____	3. _____	4. _____
3. _____ 6. _____	<u>Frame 8</u>	<u>Frame 11</u>
<u>Frame 4</u>	1. _____ 4. _____	1. _____ 3. _____
1. _____ 2. _____	2. _____ 5. _____	2. _____ 4. _____
	3. _____	

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3ABR42331-WB-313

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Technical Training

Aircraft Environmental System Mechanic

MAINTENANCE OF ANTI-G SUIT VALVE

21 February 1975



CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR42231-WB-313, 24 August 1973.

OPR: TAS

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MAINTENANCE OF ANTI-G SUIT VALVE

OBJECTIVE

After completing this workbook, you will be able to inspect and bench test the anti-G suit valve. You will follow procedures given in TO 9P5-3-12-3, Anti-G Suit Valve (Overhaul). You must complete this project with 80% accuracy. The instructor will provide minimum assistance to help you complete the project.

EQUIPMENT

	Basis of Issue
Electrical-Pneumatic Trainer (3038)	1/2 students
Anti-G Suit Valve	1/student
Ground Laboratory Test Kit	1/4 students
TO 9P5-3-12-3	1/student
Pliers, Snap Ring	1/student
Screwdriver, Common 5 inch	1/student
Wrench, Adjustable Jaw	1/student

PROCEDURE

Caution: If you have any questions about the equipment, ask your instructor for directions. REMOVE ALL YOUR JEWELRY NOW.

INTRODUCTION

1. Obtain an anti-G suit valve, part number (P/N) 10050 from locker number 2.
2. Obtain snap-ring pliers and a screwdriver from locker number 2, and the wrenches from locker number 3.
3. Obtain a ground laboratory test kit from locker number 1.
4. Obtain TO 9P5-3-12-3, Anti-G Suit Valve (Overhaul), from the limited TO file located at the front of the laboratory.
5. Read the Introduction section of TO 9P5-3-12-3, then complete the following statements.
 - a. Overhaul and test instructions for anti-G suit valve P/N 10050 are given in Sections _____ and _____.
 - b. Additional overhaul and test instructions for anti-G suit valves P/N 12800 and P/N 13500 are given in Section _____.

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c. All parts removed in the process of disassembly are replaced using parts from a _____.

d. Removed parts and residue from the repair kits are _____.

6. Read the cleaning and inspection paragraphs of TO 9P5-3-12-3, then complete the following statements.

a. All removed parts are cleaned using a _____ and dry cleaning solvent P/N _____.

b. All screws and bolts are inspected for _____.

c. Cleaned parts are dried using _____.

d. All washers and spacers are inspected for _____.

e. The component parts of the anti-G suit valve are inspected for _____.

f. Table _____ gives additional inspection requirements.

g. The table lists inspection requirements for the housing as _____ and the remedy is _____.

Note: Have the instructor check your answers.

BENCH TEST AND ADJUSTMENT

First Stage Relief Valve

1. Locate the Overhaul Instructions Section of TO 9P5-3-12-3. Read the general paragraph for testing the anti-G suit valve, and the paragraph for testing the first stage relief valve. Complete the following statement.

a. The first stage relief valve is identified in figure _____ as index number _____.

2. Locate the first stage relief valve on the anti-G suit valve. Refer to figure 1 of this text. Use the adjustable jaw wrench to remove the valve.

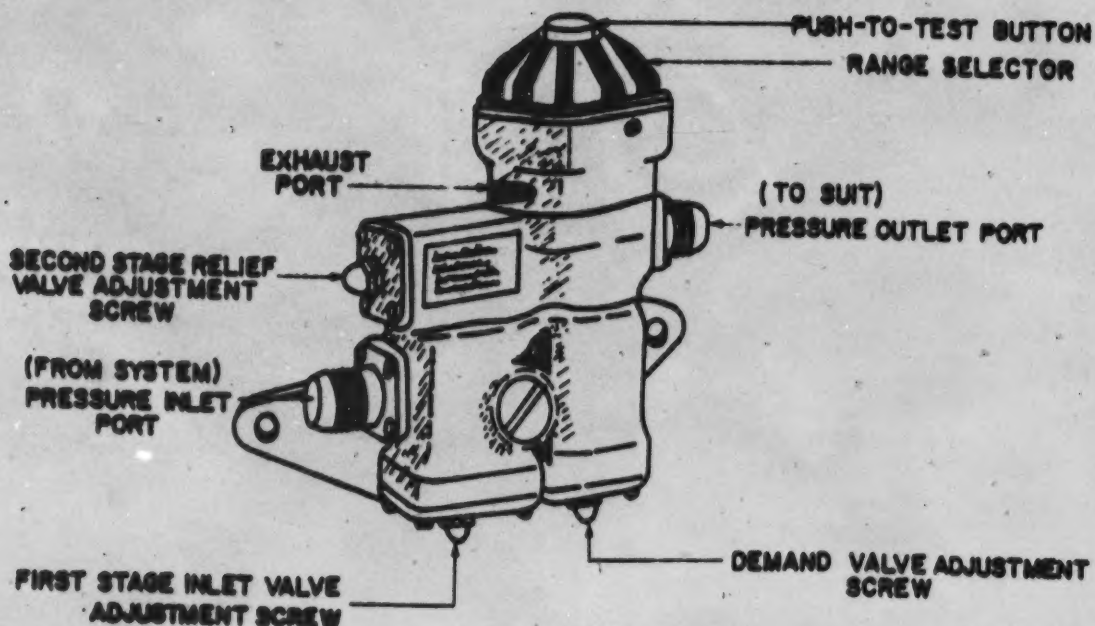


Figure 1. Anti-G Suit Valve (Part Number 10050).

3. Inspect the valve as required by TO 9P5-3-12-3. The valve is satisfactory _____ (yes/no). If unsatisfactory inform the instructor.

4. Remove the test adapter from the ground laboratory test kit. The test adapter consists of an elbow and hose adapter. Refer to figure 2 of this workbook. Install the hose adapter and first stage relief valve in the test adapter elbow.

5. Refer to figure 3 of this workbook. Connect the test adapter to the trainer as illustrated. Use the air hoses located on the bottom of the trainer to make the connections.

Note: Check each of the following steps as you complete it.

- a. _____ Close valve V3 (clockwise) and regulator R3 (counterclockwise).
- b. _____ Connect a hose between the test adapter and D6 of the trainer.
- c. _____ Connect a hose between D7 and D4 of the trainer.
- d. _____ Locate manometer M4; set it to read on the psi scale that is calibrated to read from zero.

Note: Have the instructor check your statements and hook-up before you continue.

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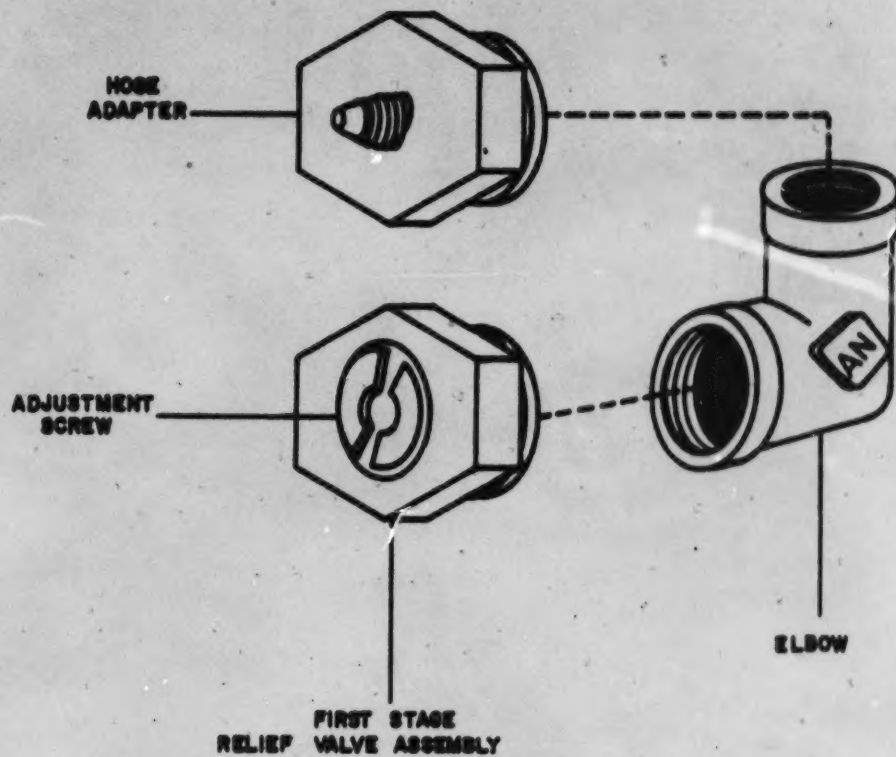
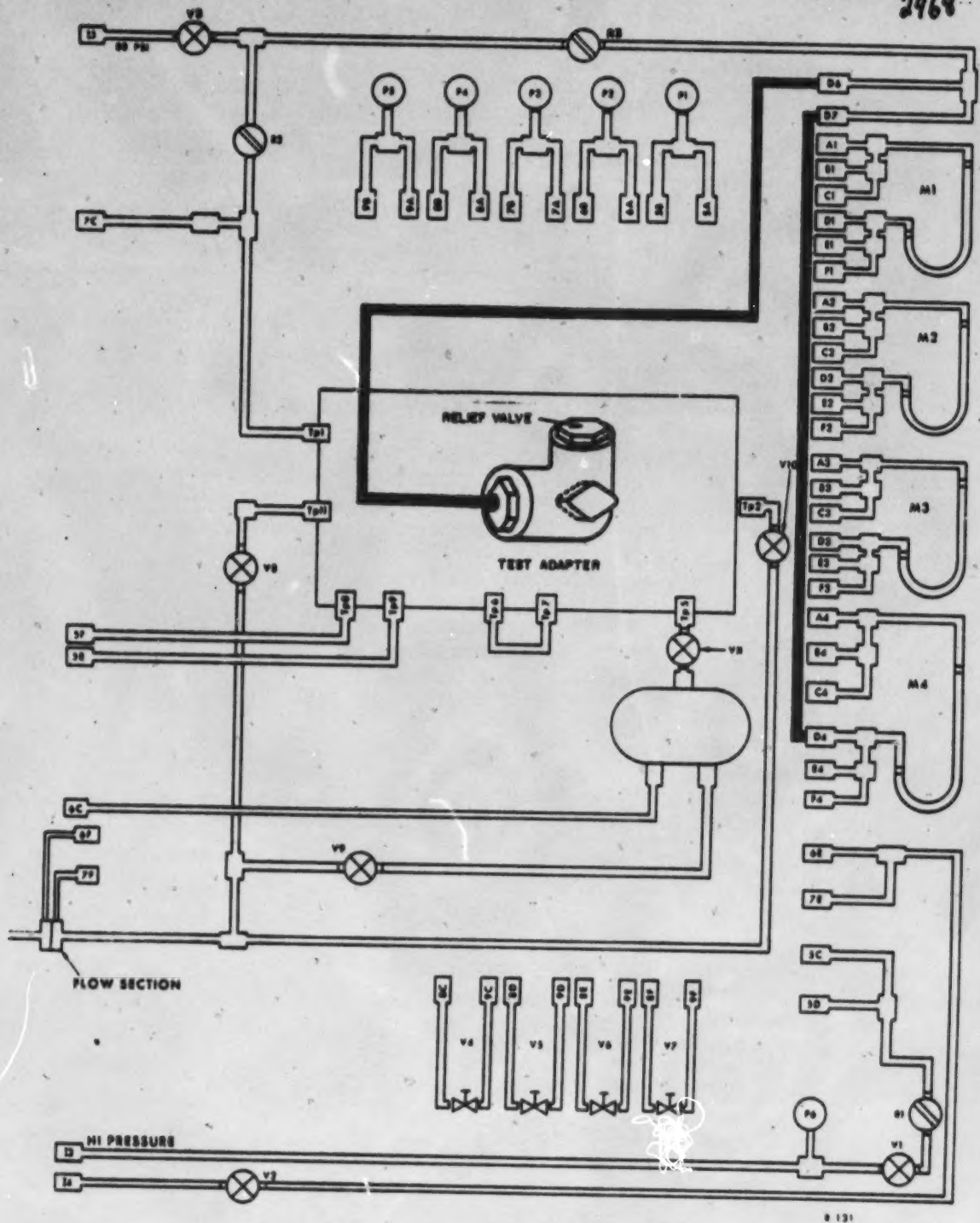


Figure 2. First Stage Relief Valve and Test Adapter.

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2469 6. Read the paragraph in TO 9P5-3-12-3, that gives instructions on testing the first stage relief valve. Complete the following questions/statement.

a. If the first stage relief valve is open below 24 psi, what action should be taken? _____

b. If the first stage relief valve is closed above 27 psi, what action should be taken? _____

c. The reading on manometer M4 at the point of opening should be between _____ to _____ psi.

7. Open valve V3 to apply air pressure to the trainer.

8. Observe manometer M4 while applying air pressure to the first stage relief valve. DO NOT EXCEED THE MAXIMUM PRESSURE SETTING (27 psi) for the first stage relief valve. Slowly turn regulator R3 clockwise until the relief valve opens. You will hear air escaping from the valve.

9. The first stage relief valve opens at _____ psi.

Note: Refer to figure 2 of this workbook. If adjustment is needed, locate the adjustment screw and adjust as needed.

10. After adjustment the first stage relief valve opens at _____ psi, which should be between the TO specification of _____ to _____ psi.

11. Reduce air pressure to the first stage relief valve by slowly turning regulator R3 counterclockwise, until manometer M4 reads 0 psi.

12. After the air pressure has dropped to 0 psi, disconnect the hose from the hose adapter. Leave the hose connected to D6 of the trainer.

13. Disconnect the hose from D7. Leave the hose connected to D4 of the trainer.

14. Remove the hose adapter from the elbow of the test adapter.

15. Set the hose adapter aside for future use.

16. Remove the first stage relief valve from the elbow of the test adapter. Return the elbow to the ground laboratory test kit.

17. Arrange the parts on the workbench in an orderly manner. You should have: a hose adapter, a first stage relief valve, an anti-G suit valve, a ground laboratory test kit, and hand tools. The trainer should have: a hose connected to D4 and a hose connected to D6.

First Stage Inlet Valve Assembly

Note: This test is made to insure that the first stage inlet valve pressure reducer is maintaining the correct inlet pressure to the first stage of the anti-G suit valve.

1. Install the hose adapter in the first stage relief valve port.
2. Remove the cap from the anti-G suit valve inlet port.
3. Refer to figure 4 of this workbook as you connect the anti-G suit valve to the trainer.

Note: Check each step as you complete it.

- a. _____ Connect the anti-G suit valve, first stage relief valve port to D4 hose.
- b. _____ Connect the hose installed on D6 to 7A.
- c. _____ Connect a hose between 7B of the trainer and the anti-G suit valve, inlet port.

Note: Have the instructor check your hook-up before you continue.

4. Apply air pressure to the first stage inlet valve assembly by slowly turning regulator R3 clockwise.

Note: As air pressure is supplied to the first stage inlet valve assembly, gage P3 and manometer M4 indicators should rise together, until both indicate an air pressure of 21 to 22 psi. As air pressure is increased, gage P3 will continue to rise. Manometer M4 should remain at 21 to 22 psi. This is the specified pressure setting for the first stage inlet valve assembly.

5. Slowly increase air pressure until gage P3 indicates 30 to 35 psi. If manometer does not remain at the specified air pressure, notify your instructor. Do not make any adjustments at this time. Read the adjustment procedures in TO 9P5-3-12-3. Figure 2-1, index 19 of the TO locates the adjustment screw on the anti-G suit valve. Figure 1 of this workbook also locates the adjustment screw. Refer to figure 2-1 of the TO. Nut (index 14) must be removed. Loosen lock nut (index 15) before turning the adjustment screw. Turn the screw clockwise or counterclockwise until the desired pressure is indicated on manometer M4. After the adjustment is made, the adjustment screw must be held in place before tightening the lock nut. After the lock nut has been tightened, install and secure nut (index 14).

6. Reduce air pressure by slowly turning regulator R3 counterclockwise.

7. After air pressure has dropped to 0 psi, disconnect the hose from the hose adapter. Leave the hose connected to D4.

8. Do not remove the hose connecting 7A and D6.

**Figure 4. First Stage Inlet Valve Assembly Test Hook-up
Electrical-Pneumatic Trainer (Schematic).**

9. Remove the hose adapter from the first stage relief valve port.
10. Install the first stage relief valve in the anti-G suit valve and tighten securely.
11. Return the hose adapter to the ground laboratory test kit.
12. Arrange the parts on the workbench in an orderly manner. You should have: a ground laboratory test kit, a cap, and hand tools. The trainer should have: a hose connected to D4, a hose connected between 7B and the anti-G suit valve inlet port, and a hose connected between 7A and D6.

Second Stage Relief Valve

Note: This test is made to insure air pressure in the second stage does not exceed the specified air pressure.

1. Read the paragraph in TO 9P5-3-12-3, that gives instructions on testing the second stage relief valve. Complete the following statements.

- a. The outlet gage (manometer M4) indicates the maximum pressure setting of the valve as ____ psi.

- b. Manometer M4 indicates the minimum pressure setting of the valve as ____ psi.

2. Refer to figure 5 of this text as you connect the anti-G suit valve to the trainer.

Note: Check each step as you complete it.

- a. ____ Remove the cap from the anti-G suit valve outlet port.
- b. ____ Connect the D4 hose to the anti-G suit valve outlet port.

Note: Have the instructor check your hook-up before you continue.

3. Slowly turn regulator R3 clockwise until gage P3 indicates 20 psi.
4. Depress the anti-G suit valve, push-to-test button and hold it down.
5. Observe the pressure indication on manometer M4 as air escapes from the second stage relief valve.
6. Manometer M4 indicates ____ psi, when the second stage relief valve opened.

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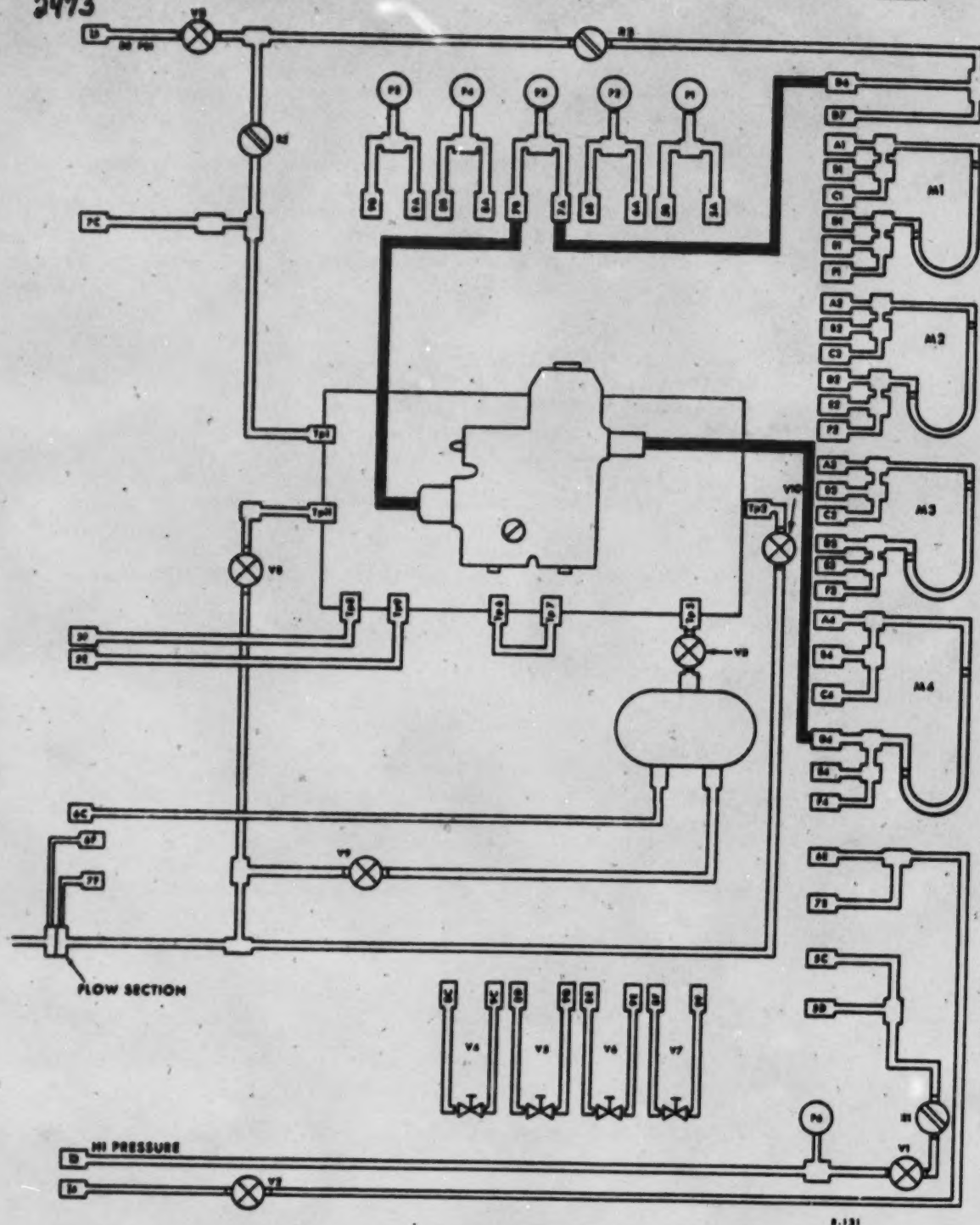


Figure 5. Second Stage Relief Valve Test Hook-up
Electrical-Pneumatic Trainer (Schematic).

7. If the pressure setting is not within the maximum and minimum range, notify your instructor. Do not make any adjustments at this time. Read the adjustment procedures in TO 9P5-3-12-3. Figure 2-2, index 6 of the TO locates the adjustment screw on the anti-G suit valve. Figure 1 of this workbook also locates the adjustment screw. Refer to figure 2-2 of the TO. Nut (index 1) must be removed. Loosen lock nut (index 2) before turning the adjustment screw. Turn the screw clockwise or counterclockwise until the desired pressure is indicated on manometer M4. After the adjustment is made, the adjustment screw must be held in place before tightening the lock nut. After the lock nut has been tightened, install and secure nut (index 1).

8. Reduce air pressure to the valve by slowly turning regulator R3 counterclockwise.

9. After air pressure has dropped to 0 psi, disconnect the hose from the anti-G suit valve, inlet port. Leave the hose connected to 7B.

10. Do not remove the hose connecting 7A and D6.

11. Disconnect the hose from the anti-G suit valve, outlet port and D4.

12. Arrange the parts on the workbench in an orderly manner. You should have: a hose, a ground laboratory test kit, two (2) caps, and hand tools. The trainer should have: an anti-G suit valve, a hose connected between 7A and D6, and a hose connected to 7B.

Demand Valve

Preparation Step

1. Remove the "L" shaped bracket and mounting nuts from the ground laboratory test kit.

2. Hold the anti-G suit valve in your left hand. The push-to-test button must be up and the identification (ID) plate facing you. Insert the "L" shaped bracket from front to rear. Secure the valve to the anti-G suit bracket with the mounting nuts.

3. Mount the anti-G suit valve on the tester.

4. Refer to figure 6 of this workbook. Use the snap-ring pliers to remove the snap-ring that holds the push-to-test button in place. Set the snap-ring aside for reassembly after the test is completed.

5. Remove the push-to-test button and pin assembly.

6. Remove the spring. Set aside for reassembly after the test is completed.

7. Place only the push-to-test button and pin assembly back on the valve.

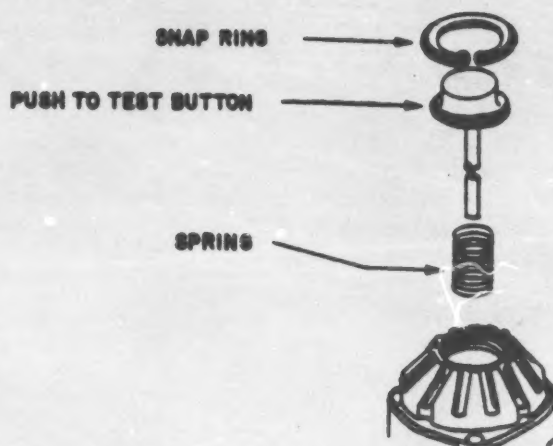


Figure 6. Range Selector.

8. Refer to figure 7 of this workbook as you connect the anti-G suit valve to the trainer.

Note: Check each step as you complete it.

a. _____ Connect a hose between the anti-G suit valve outlet and TP5 on the trainer.

b. _____ Connect a hose between 6C and F4 on the trainer.

Note: Have the instructor check your hook-up before you continue.

Acceleration Test (LO Position)

1. Set the range selector of the anti-G suit valve to the LO position.

2. Remove the LO weights and LO adapter from the ground laboratory test kit and arrange them on the workbench.

Note: The LO (low) weights are solid and are marked LO. The LO adapter is used to hold the LO weights on the push-to-test button. The adapter has a G unit value of 0.5 G and the weights range in value from 0.25 G to 4.0 Gs.

3. Slowly turn regulator R3 clockwise until gage P3 indicates 40 psi.

4. Slowly open valve V11, this allows air pressure to be directed to manometer M4.

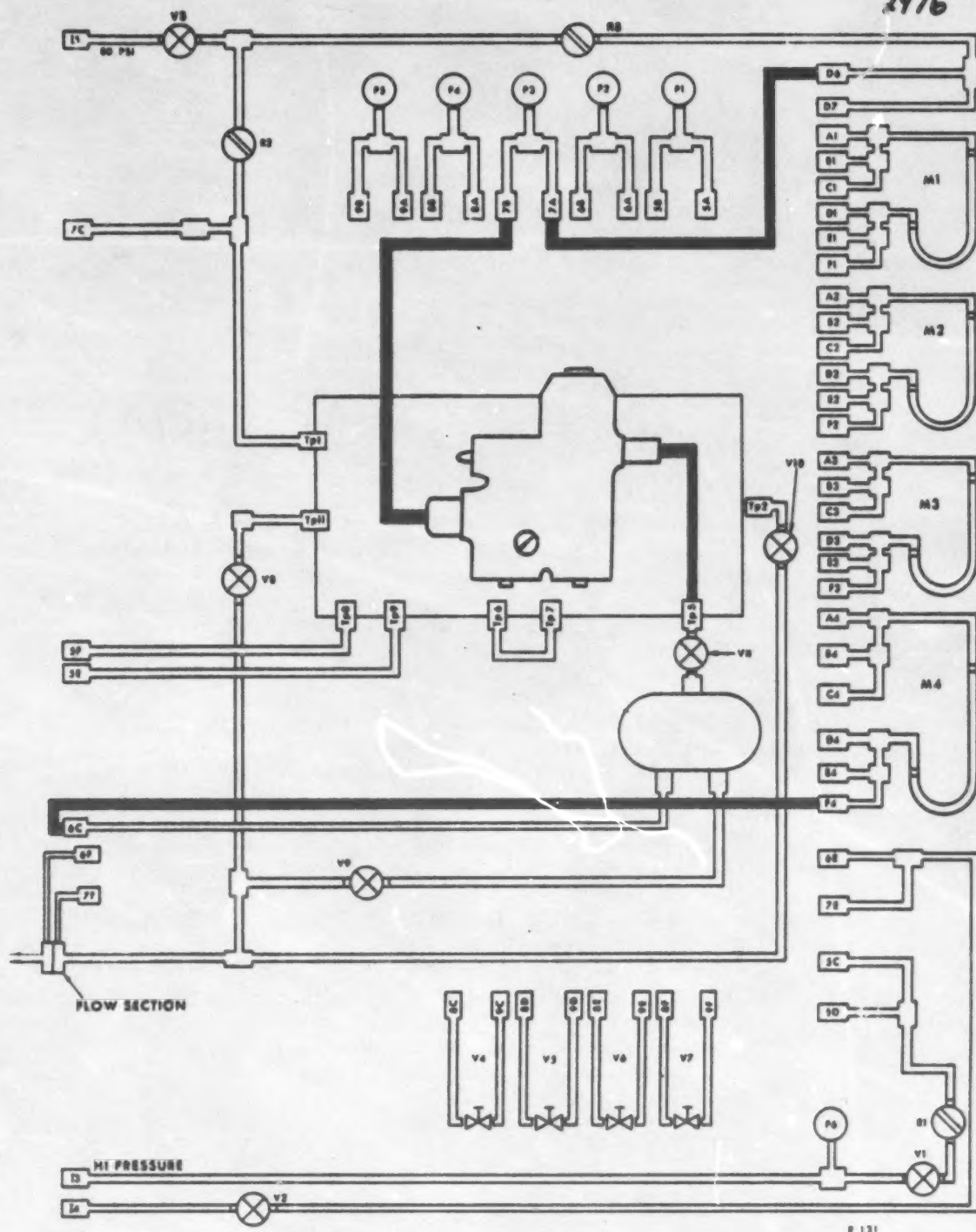


Figure 7. Demand Valve Test Hook-up
Electrical-Pneumatic Trainer (Schematic).

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5. Refer to TI 9P5-3-12-3, Table 3-2. The table lists the weights used when simulating a total "G" load test. Use the table to determine the weight needed to perform the following tests.

LO RANGE TESTS

2.0 G _____ psi

8.0 G _____ psi

Note: Table 3-2 in TO 9P5-3-12-3 takes into account the 1 G weight that is inside the anti-G suit valve for both the LO and HI tests.

6. Assemble on the LO adapter the weight needed to perform a LO range test. Place the adapter and weights on the push-to-test button. Observe manometer M4 and record the readings for each test.

Note: Make certain the "G" weights and adapter are resting firmly on the push-to-test button and are not leaning. Rotate the weights and adapter slowly during the test, until the readings are constant. This insures that the weights and adapter are bearing full force on the demand valve.

7. Refer to figure 8 of this text. The LO Range Graph indicates the air pressure required for a given number of "G" units. The pressure indicated by manometer M4 should fall between the two diagonal lines. The vertical lines indicate the value of the weights (G units) placed on the push-to-test button. Read from this line horizontally to the pressure (psi) indicated by manometer M4. If the manometer pressure indication does not fall between the diagonal lines, an adjustment must be made to the demand valve.

8. If manometer M4 does not remain at the specified air pressure, notify the instructor. Do not make any adjustment at this time.

Note: Read the adjustment procedures in TO 9P5-3-12-3. Figure 2-3, index 27 of the TO locates the adjustment screw on the anti-G suit valve. Figure 1 of this workbook also locates the adjustment screw. Refer to figure 2-3 of the TO. Nut (index 22) must be removed. Loosen lock nut (index 23) before turning the adjustment screw. Turn the screw clockwise or counterclockwise until the desired pressure is indicated on manometer M4. After the adjustment is made, the adjustment screw must be held in place before tightening the lock nut. After the lock nut has been tightened, install and secure nut (index 22).

9. Remove the LO weights and adapter from the push-to-test button.

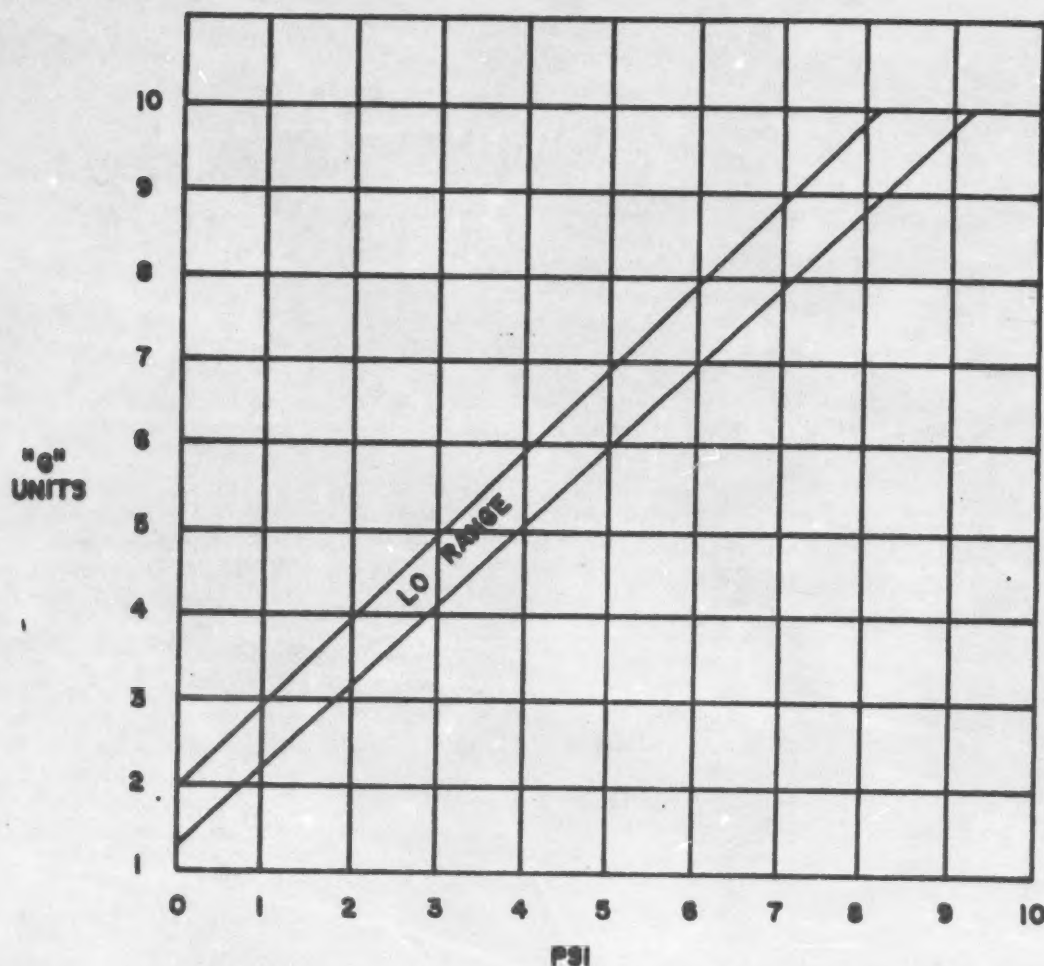


Figure 8. LO Range Graph.

Acceleration Test (HI Position)

1. Set the range selector of the anti-G suit valve to the HI position.
2. Remove the HI weights and HI adapter from the ground laboratory test kit. Arrange the LO and HI weights and adapters on the workbench.

Note: The HI (high) weights and HI adapter are marked HI. The weights are recessed to receive the LO weights. Both the HI and LO weights are used to perform the HI range tests. The G unit value of the HI weights and adapter is the same as for the LO weights and adapter. The LO adapter is not used for HI range tests; return it to the test kit.

3. Refer to TO 9P5-3-12-3, Table 3-2. The table lists the weights used when simulating a total "G" load test. Use the table to determine the weight needed to perform the following tests.

HI RANGE TESTS

2.0 G _____ psi

6.0 G _____ psi

8.0 G _____ psi

4. Assemble on the HI adapter the LO and HI weights needed to perform a HI range test. Place the adapter and weights on the push-to-test button. Observe manometer M4 and record the readings for each test.

Note: Make certain the "G" weights and adapter are resting firmly on the push-to-test button and are not leaning. Rotate the weights and adapter slowly during the test, until the readings are constant. This insures that the weights and adapter are bearing full force on the demand valve.

5. Refer to figure 9 of this workbook. The HI Range Graph indicates the air pressure required for a given number of "G" units. The pressure indicated by manometer M4 should fall between the two diagonal lines. The vertical lines indicate the value of the weights (G units) placed on the push-to-test button. Read from this line horizontally to the pressure (psi) indicated by manometer M4. If the manometer pressure indication does not fall between the diagonal lines, an adjustment must be made to the demand valve.

6. If manometer M4 does not remain at the specified air pressure, notify the instructor. Do not make any adjustment at this time.

Note: Read the adjustment procedures in TO 9P5-3-12-3. Figure 2-3, index 27 of the TO locates the adjustment screw on the anti-G suit valve. Figure 1 of this workbook also locates the adjustment screw. Refer to figure 2-3 of the TO. Nut (index 22) must be removed. Loosen lock nut (index 23) before turning the adjustment screw. Turn the screw clockwise or counterclockwise until the desired pressure is indicated on manometer M4. After the adjustment is made, the adjustment screw must be held in place before tightening the lock nut. After the lock nut has been tightened, install and secure nut (index 22).

7. Remove the LO and HI weights and HI adapter from the push-to-test button.

Shut-Down Steps

1. Reduce air pressure to the anti-G suit valve by slowly turning regulator R3 counterclockwise.

2. Close valve V3 to shutoff pressure to the trainer.

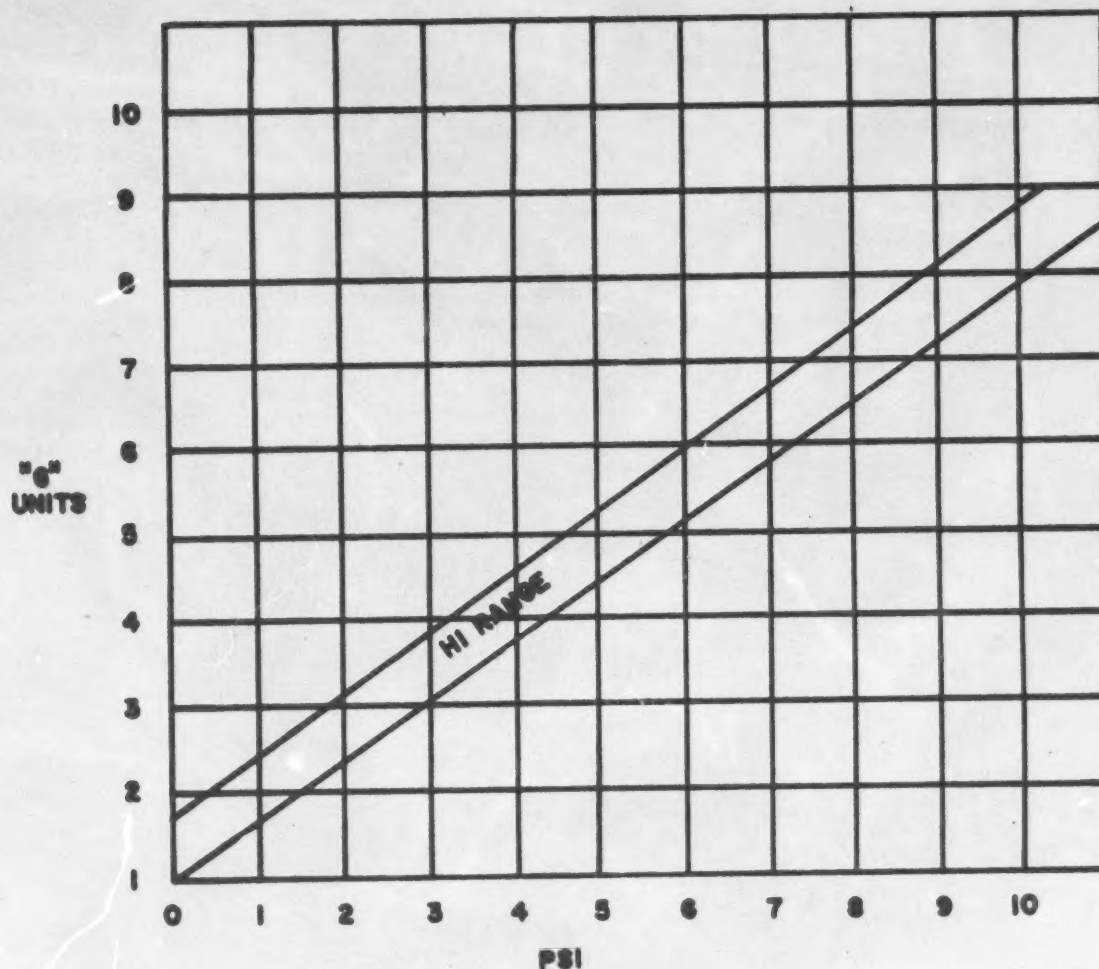


Figure 9. HI Range Graph.

3. Close valve V11 to shutoff pressure to manometer M4.
4. After air pressure has dropped to 0 psi, disconnect the hose between D6 and 7A. Store the hose in the bottom of the trainer.
5. Disconnect the hose between TP5 and the anti-G suit valve outlet port. Plug and store the hose in the bottom of the trainer.
6. Disconnect the hose between 7B and the anti-G suit valve inlet port. Plug and store the hose in the bottom of the trainer.
7. Disconnect the hose between 6C and F4. Plug and store the hose in the bottom of the trainer.
8. Remove the push-to-test button and pin assembly from the anti-G suit valve.

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9. Install the spring, push-to-test button and pin assembly, and snap ring back on the valve.
10. Remove the anti-G suit valve from the tester.
11. Remove the "L" shaped bracket from the anti-G suit valve. Return the "L" shaped bracket and mounting nuts to the ground laboratory test kit.
12. Return the LO weights, HI weights, and HI adapter to the ground laboratory test kit. Store the test kit in locker number 1.
13. Cap all openings of the anti-G suit valve. Store the anti-G suit valve, snap-ring pliers, and screwdriver in locker number 2.
14. Store the wrenches in locker number 3.
15. Clean the trainer, workbench and work area.

Note: Check with the instructor for further instructions.

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RESPONSE SHEET 3ABR42231-WB-313

MAINTENANCE OF ANTI-G SUIT VALVE

INTRODUCTION

5a. _____

5b. _____

5c. _____

5d. _____

6a. _____

6b. _____

6c. _____

6d. _____

6e. _____

6f. _____

6g. _____

FIRST STAGE RELIEF VALVE

1a. _____

3. _____

5a. _____ 5c. _____

5b. _____ 5d. _____

6a. _____

6b. _____

6c. _____

9. _____

FIRST STAGE INLET
VALVE ASSEMBLY

4a. _____ 4c. _____

4b. _____

SECOND STAGE RELIEF VALVE

1a. _____ 1b. _____

2a. _____ 2b. _____

6. _____

DEMAND VALVEPreparation Step

8a. _____ 8b. _____

Acceleration Test
(LO Position)

5. 2.0 G _____ psi

3.0 G _____ psi

8.0 G _____ psi

Acceleration Test
(HI Position)

5. 2.0 G _____ psi

6.0 G _____ psi

8.0 G _____ psi

2483

RESPONSE SHEET 3ABR42231-WB-313

MAINTENANCE OF ANTI-G SUIT VALVE

INTRODUCTION

5a. _____

5b. _____

5c. _____

5d. _____

6a. _____

6b. _____

6c. _____

6d. _____

6e. _____

6f. _____

6g. _____

FIRST STAGE RELIEF VALVE

1a. _____

3. _____

5a. _____ 5c. _____

5b. _____ 5d. _____

6a. _____

6b. _____

6c. _____

9. _____

FIRST STAGE INLET
VALVE ASSEMBLY

4a. _____ 4c. _____

4b. _____

SECOND STAGE RELIEF VALVE

1a. _____ 1b. _____

2a. _____ 2b. _____

6. _____

DEMAND VALVEPreparation Step

8a. _____ 8b. _____

Acceleration Test
(LO Position)

5. 2.0 G _____ psi

3.0 G _____ psi

8.0 G _____ psi

Acceleration Test
(HI Position)

5. 2.0 G _____ psi

6.0 G _____ psi

8.0 G _____ psi

652

2484



PROGRAMMED TEXT 3ABR42331-PT-314

Technical Training

Aircraft Environmental Systems Mechanic

CANOPY SEAL SYSTEM

20 August 1975



CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR42231-PT-314, 18 September 1972; 3ABR42231-PT-409A, 27 May 1971.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 2

Designed For ATC Course Use

DO NOT USE ON THE JOB

73-24634

Study Guides and Workbooks are training publications authorized by Air Training Command (ATC) for student use in ATC courses.

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Training publications are designed for ATC use only. They are updated as necessary for training purposes, but are NOT to be used on the job as authoritative references in preference to Technical Orders or other official publications.

FOREWORD

This programmed text was prepared for use in the 3ABR42231 instructional system. The material contained herein has been validated using thirty 42010 students enrolled in the 3ABR42231 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 0.5 hour to complete the text.

OBJECTIVES

1. Identify each component.
2. Explain the function of each component.
3. Trace the flow of air through the system for normal and testing operation.
4. Explain the purpose and analyze system operation.

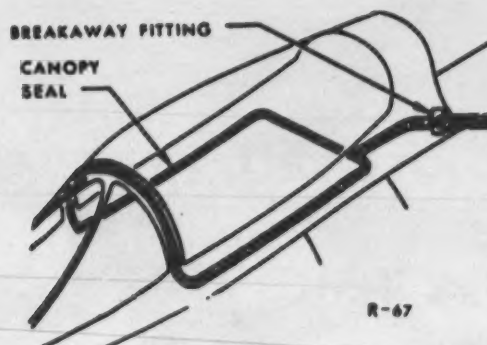
INSTRUCTIONS

NOTE: BEFORE PROCEEDING, REMOVE THE RESPONSE SHEET AT THE BACK OF THIS TEXT. ENTER YOUR ANSWERS FOR FRAME EXERCISES ON THE RESPONSE SHEET.

This programmed text presents information in small steps called "frames." After each frame, you are expected to respond by supplying a word, or words, to complete the sentence, choose either a true or false statement, select the correct answer, or match some term to their proper meaning.

Read the material presented, select your response(s) as required at the end of the frame. After you have made your selection check your responses on the top of the next page. DO NOT MARK IN THIS TEXT. If your selections were correct, go on to the next frame and repeat the above process. If you made an incorrect response, reread the frame until you understand your error.

High altitude aircraft use a pressurization system for the comfort and safety of the crew. The canopy seal (inflatable tube) is located between the canopy and the aircraft fuselage, see below. When this seal is inflated it will stop the loss of cockpit pressure when air pressure inside the aircraft is more than the air pressure outside of the aircraft. The seal can be fastened to the aircraft or the canopy and give the same results. A regulator is put in the system to control pressure in the seal. By controlling pressure, the regulator will keep the seal from rupturing.



Answer the statements (T) or false (F).

- a. The canopy seal prevents the loss of cockpit pressure.
- b. The canopy seal is always fastened to the canopy.
- c. Low pressure in the seal will cause it to rupture.
- d. The canopy seal prevents a loss of cabin pressure at any altitude.
- e. The canopy seal regulator controls pressure in the cockpit.
- f. The canopy seal is inflated to make the proper seal.

2487

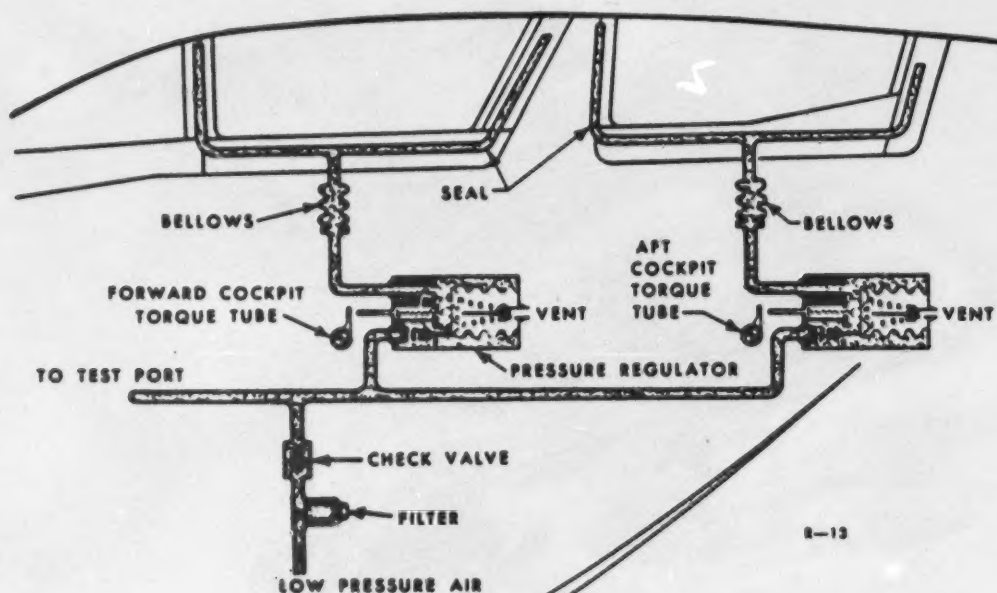
Answers to Frame 1: a. T, b. F, c. T, d. F,
e. F, f. T

Frame 2

The seal is made of rubber. When regulated air pressure is applied, the seal expands and makes a seal between the canopy and the cockpit.

Identify the statement that tells how the canopy seal makes the canopy airtight.

- a. By sea level air pressure in the seal, causing it to expand at altitude.
- b. By applying a constant regulated air pressure to the seal, causing it to expand.
- c. By blowing the seal up as you would a car tire.



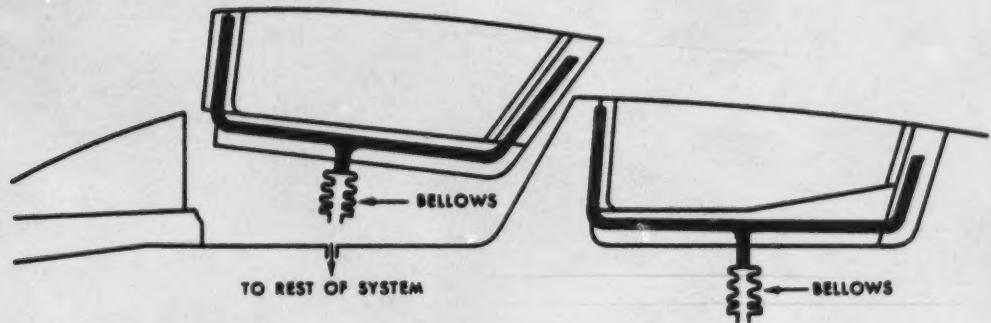
656

Answer to Frame 2: b

Frame 3

A bellows is a vented type flexible container (such as the flexible part of an accordion) that connects two units. Look at the diagram, the bellows in the canopy seal system is used to

- a. vent the canopy seal to the atmosphere.
- b. vent the canopy seal to the cockpit.
- c. provide a test port connection.
- d. connect the canopy seal to the rest of the system when the canopy is closed.



2-14

2489

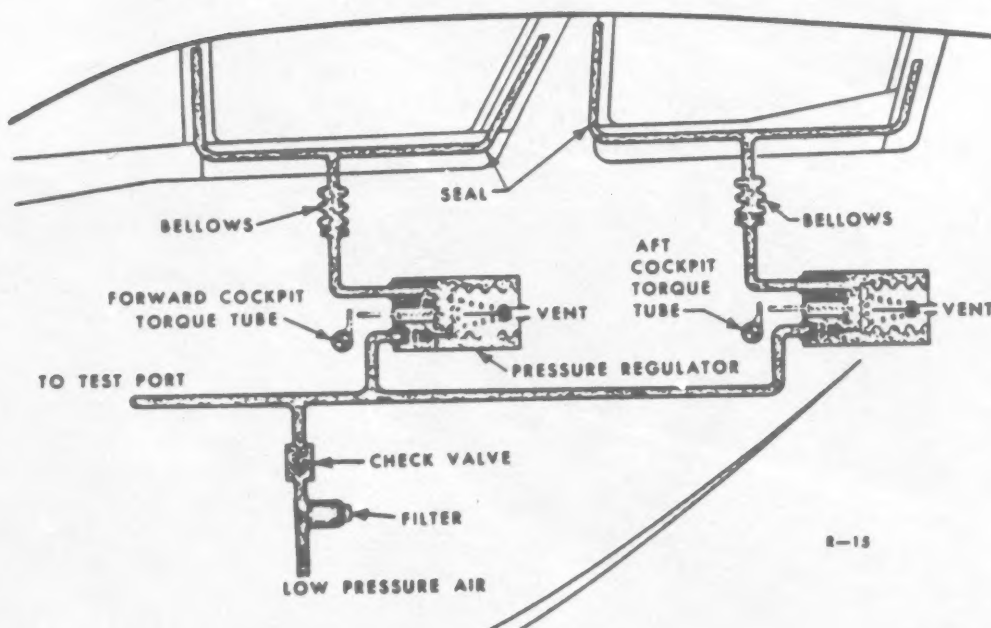
Answer to Frame 3: d

Frame 4

The canopy seal is expanded by air at a low pressure. This low pressure air is from the auxiliary air source and flows through the canopy seal regulator.

The canopy seal air pressure is regulated by the

- a. cockpit pressure regulator.
- b. air conditioning system pressure regulating and shutoff valve.
- c. canopy seal pressure regulator.



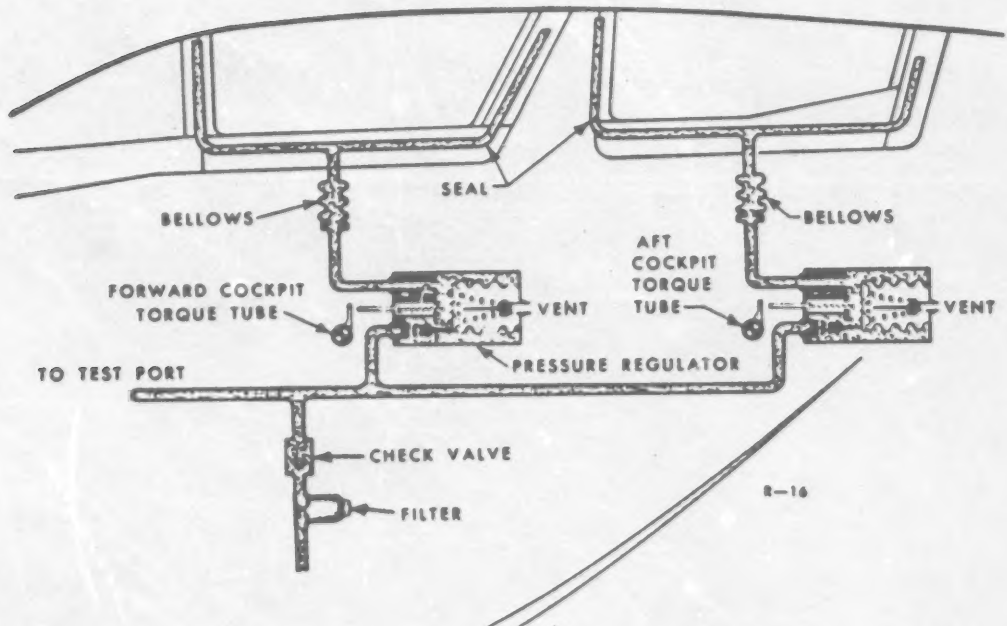
658

Frame 5

The regulator keeps a 20 to 24 psi of air pressure in the seal during pressurized flight. Operation of the regulator is covered later in the text.

Which of the following states the purpose of the canopy seal pressure regulator?

- Keeps 20 to 24 psi of air pressure to canopy seal during pressurized flight.
- Regulates the air pressure leaving the canopy seal at 20 psi.
- Keeps a 20 to 24 psi differential air pressure between the seal and cockpit pressure.



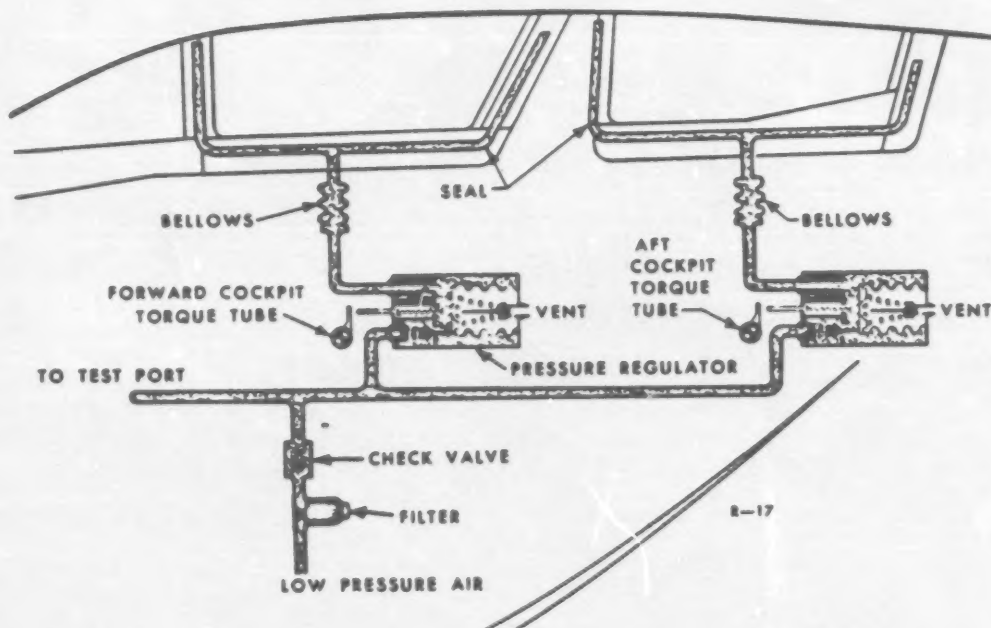
*Note: Number 2491 is missing from this text.
However, all materials are included.*

2492
Answer to Frame 5: a

Frame 6

Particles, such as soot, that may be found in the auxiliary air source could be harmful to the canopy seal and the canopy seal components. Look at the diagram. Which of the items is used to take out particles from the air used by the canopy seal system?

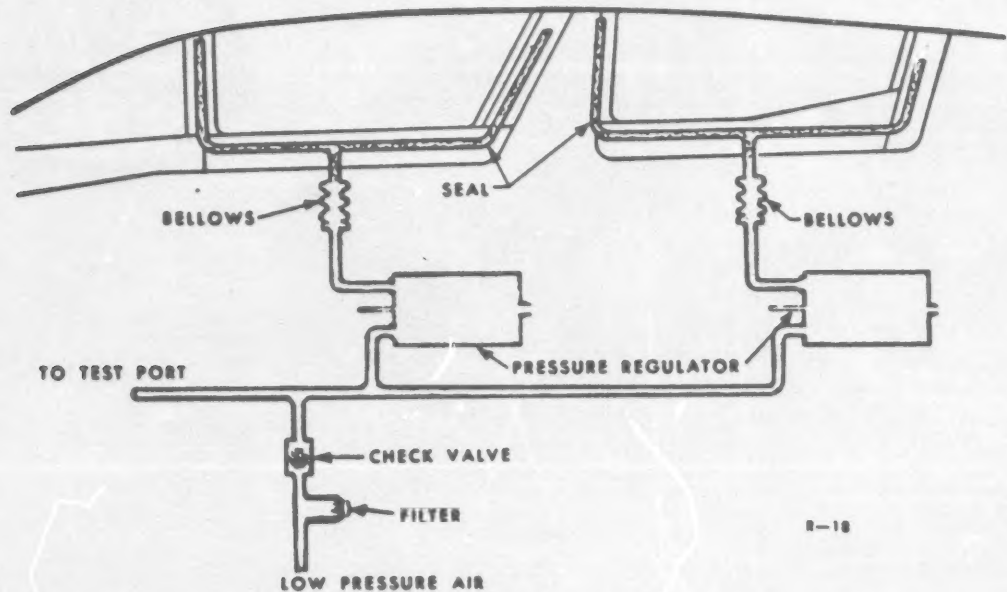
- a. Canopy Seal Bellows
- b. Filter
- c. Check Valve
- d. Pressure Regulator



Frame 7

The seal is placed in a channel of the canopy. The rest of the system is in the fuselage. Look at the diagram. Identify the statement that tells how the seal is connected to the system, when the canopy is closed.

- a. A quick disconnect fitting.
- b. A channel band clamp.
- c. Canopy seal bellows.
- d. A band clamp.



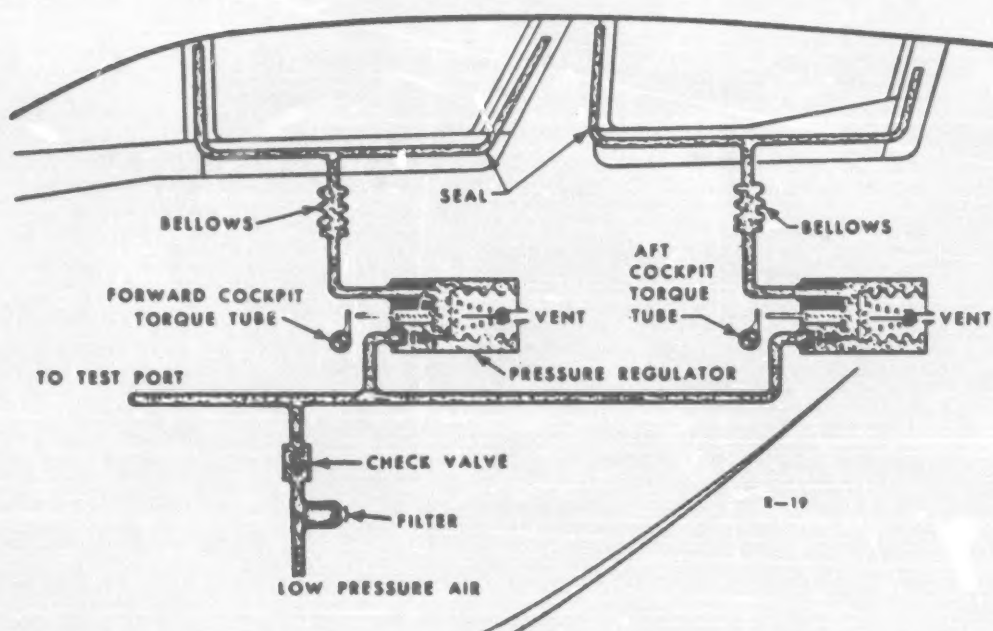
2494

Answer to Frame 7: c

Frame 8

The canopy seal check valve stops the air that flows to the seal from flowing back to the auxiliary air source, when the ground test port is used. Look at the diagram. When will the check valve stop the flow of air to the auxiliary air source?

- During all pressurized flight.
- When using the ground test port.
- When deflating the seal.

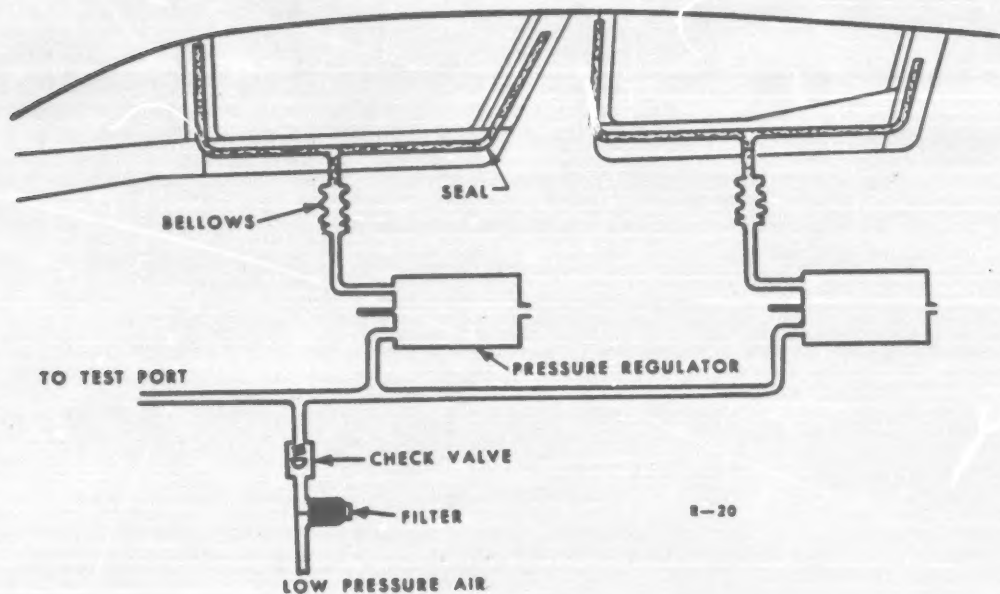


662

Frame 9

The system has a test port that is used to check for leaks and operation when the aircraft is on the ground. A ground air cart is used as a pressure source when ground checks need to be made. Which statement tells where the ground air cart is connected to the system?

- a. At the bellows.
- b. At the pressure regulator.
- c. At the filter.
- d. At the ground test port.



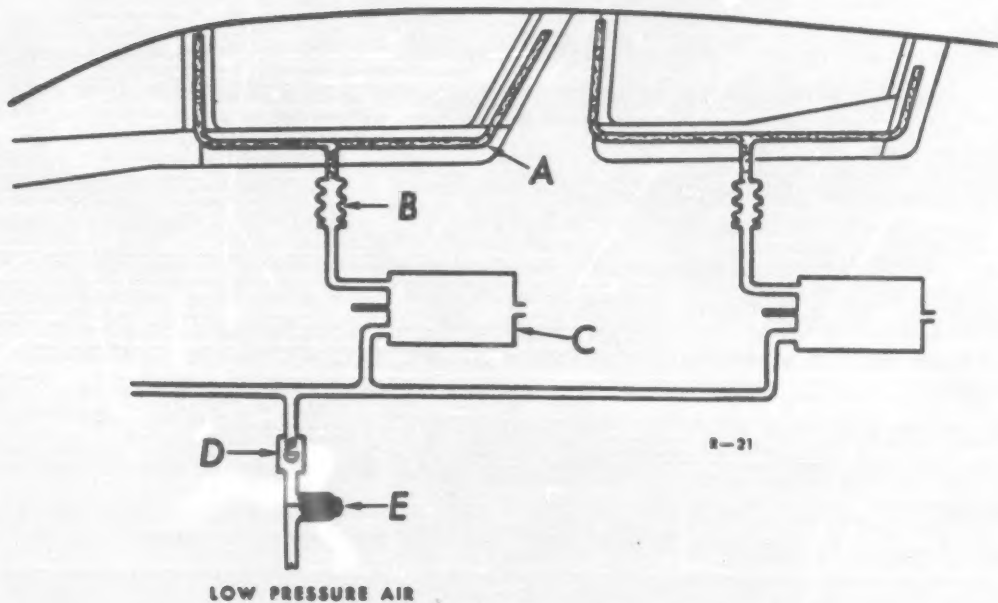
2496

Answer to Frame 9: d

Frame 10

Look at the diagram. Match the components with the letter that identifies the component in the diagram.

1. Check Valve
2. Seal
3. Regulator
4. Filter
5. Bellows



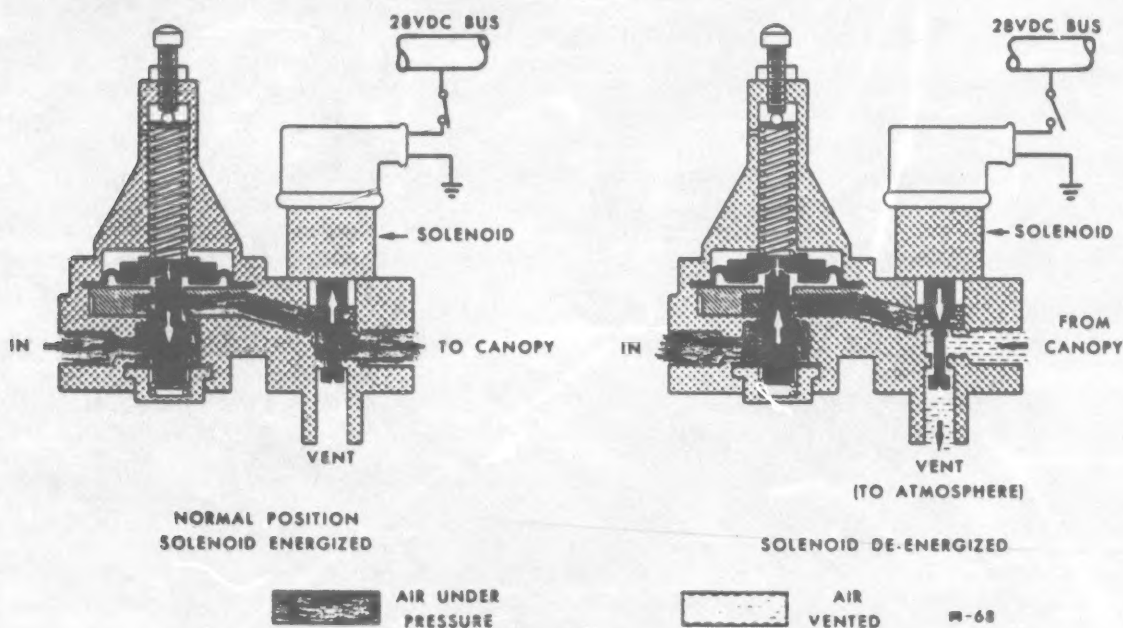
664

Answers to Frame 10: 1. D, 2. A, 3. C, 4. E,
5. B

2497

Frame 11

The canopy seal regulator controls the air in the seal to 20 and 24 psi. The regulator has a shutoff and dump valve. High pressure air is tapped off of the engine bleed air duct. A solenoid is used to control the position of the shutoff and dump valve. The solenoid is energized by 28V DC. Study the diagram below.



Canopy Seal Regulator-Flow Illustrations.

Answer the statements as true (T) or false (F).

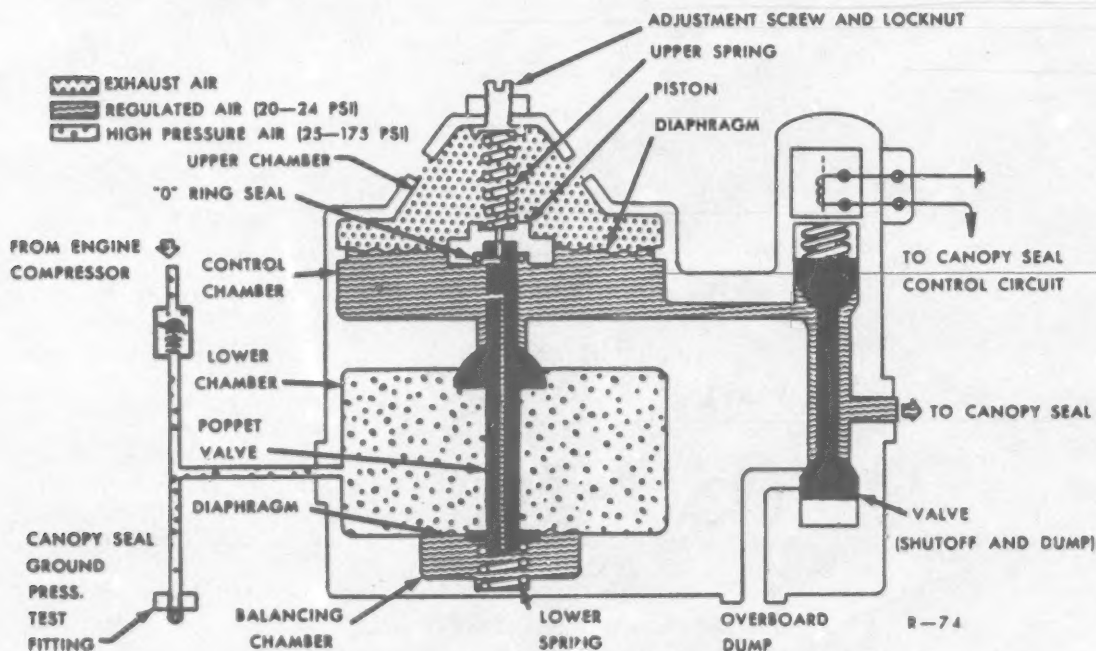
- The canopy seal regulator controls air to the canopy seal.
- The regulator maintains a pressure of 20 to 24 psi in the seal.
- Engine bleed air is used as a source of air pressure to the canopy seal regulator.
- The voltage needed to energize the solenoid is 28V DC.
- The regulator is a combination regulator, shutoff valve, and dump valve.

2498

Answers to Frame 11: a. T, b. T, c. T, d. T,
e. T

Frame 12

Look at the diagram as we discuss operation of the regulator with the canopy closed. Locate the shutoff and dump valve, upper chamber, control chamber, lower chamber and balancing chamber. When the canopy is closed, it energizes the solenoid. The solenoid can then pull the shutoff and dump valve UP. In this position the shutoff part of the valve opens a port for air to flow to the seal. The flow of air is from the control chamber of the regulator. The dump part of the valve will close the overboard dump port. Pressurized engine bleed air flows to the lower chamber. The top spring will force the poppet valve down and away from the seat. This takes place when there is not enough air pressure on the bottom side of the two diaphragms. Air can then flow into the control chamber and balancing chamber. When the pressure in these two chambers overcomes spring tension the poppet valve will close. This shuts off the flow of air to the canopy seal and keeps a pressure of 20 to 24 psi in the seal.



Canopy Seal Regulator-Inflating.

Answer the statements as true (T) or false (F).

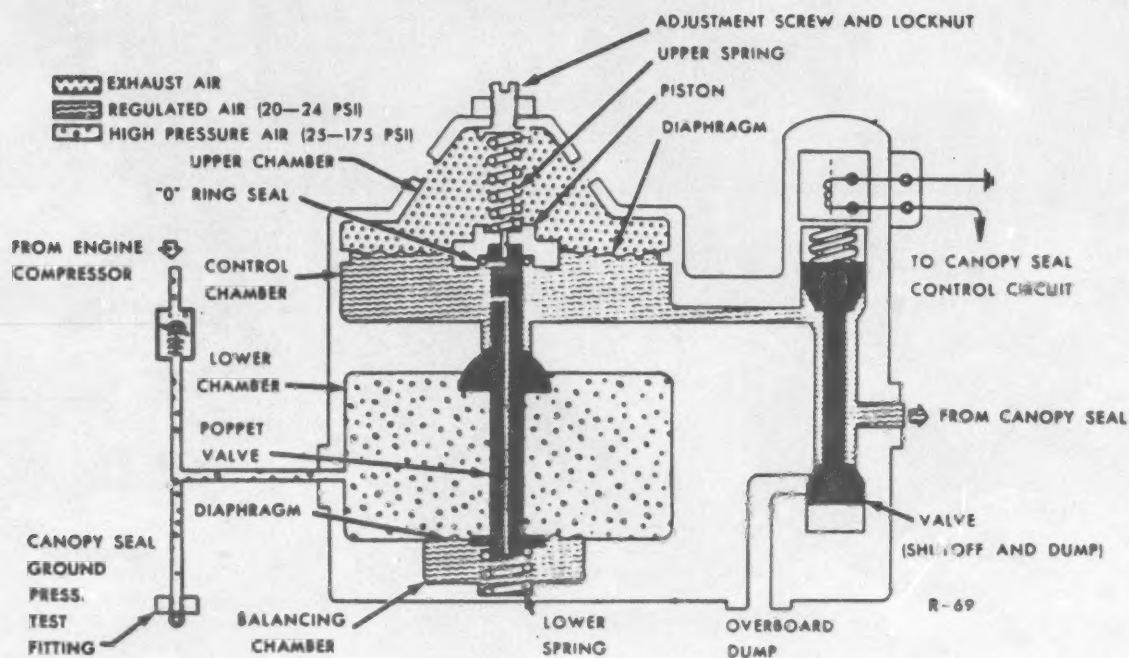
- EBA (engine bleed air) is applied to the lower chamber.
- The upper spring closes the poppet valve.
- The poppet valve closes when the upper spring compresses.
- When the poppet valve closes there is a pressure of 20 - 24 psi in the seal with the solenoid energized.

Answers to Frame 12: a. T, b. F, c. T, d. T

2499

Frame 13

Look at the diagram as we discuss operation of the system with the canopy open. When the canopy is opened the solenoid is deenergized. The spring can then push the shutoff and dump valve down. The shutoff part of the valve stops the flow of regulated air to the seal. Air in the seal can flow past the dump part of the valve and will vent overboard.



Canopy Seal Regulator-Deflating.

Answer the statements as true (T) or false (F).

- When the canopy is opened the solenoid deenergizes.
- When the solenoid deenergizes, spring tension opens the dump valve and closes the shutoff valve.
- When the solenoid energizes, the dump valve closes and the shutoff valve opens.
- When the solenoid deenergizes the air flows from the canopy seal to the overboard dump.

2500

Answers to Frame 13: a. T, b. T, c. T, d. T

Frame 14

That is about it for the canopy seal system. The next thing you will do is adjust the canopy seal regulator. You will do this in the next project.

No Response Required

668

Environmental Pneudraulic Branch
 Chanute AFB, Illinois

3ABR42331-WB-314
 26 February 1976

MAINTENANCE OF CANOPY SEAL REGULATORS

OBJECTIVES

Using this workbook, TO, and trainer, you will:

1. Inspect a canopy seal regulator.
2. Bench test a canopy seal regulator.

Standard of performance:

Your performance will be observed and measured against an instructor checklist. You must complete the project with 100% accuracy.

EQUIPMENT

Canopy Seal Regulator P/N 10752
 Electrical Pneumatic Trainer #3038
 4 Inch Common Screwdriver
 3/8 Inch Open-End Wrench
 TO 16R1-4-2-3

Basis of Issue
 1/student
 1/student
 1/student
 1/student
 1/student

PROCEDURE

REMOVE YOUR JEWELRY

1. Your instructor will assign you an electrical pneumatic trainer P/N 3038.
2. Go to equipment locker number 2 and get a canopy seal regulator P/N 10752.
3. Use the index on the TO file cabinet to find the overhaul with parts breakdown technical order for this regulator.
 - a. Answer the following questions:
 - (1) What is the correct TO number? _____
4. Get the correct TO from the TO file cabinet.
 - a. In the TO find the Leading Particulars for the regulator and complete the following statements.

Supersedes 3ABR42231-WB-314, 12 November 1975.

OPR: TAS

DISTRIBUTION: X

TAS - 200; TTVGC - 1

Designed for ATC Course Use. Do Not Use on the Job.

(1) Maximum inlet pressure for Regulator P/N 10752 is _____.

(2) Regulator outlet pressure for P/N 10752 is _____.

b. Using the TO find the inspection requirements and answer the following statements.

(1) Inspect all parts for evidence of _____, _____, and _____.

(2) Inspect all threaded areas for _____, _____, _____, or _____.

c. Visually inspect your regulator and list any discrepancies below.

d. TO paragraph 5, items a and b, would be followed to repair and/or replace any parts which do not meet inspection requirements.

e. Have the instructor check your answers.

5. Trainer preparation.

a. Place switches S1 and S2 in the OFF position.

b. Plug the trainer power cables in the proper wall receptacle. Make sure that all circuit breakers on the left end of the trainer are pushed in.

6. Test procedures.

a. Refer to the hookup shown in figure 1 to complete the following steps.

b. Connect the two wires on the regulator to the correct electrical pins on the trainer electrical patch panel. Note: It does not matter which wire of the solenoid goes to D or R on the trainer electrical patch panel.

c. The hoses are indicated by heavy black lines in figure 1. Get the hoses from the bottom of the trainer. Connect the hoses to the regulator as shown. Do Not use a wrench to tighten the "B" nut as finger tightness is sufficient for this test.

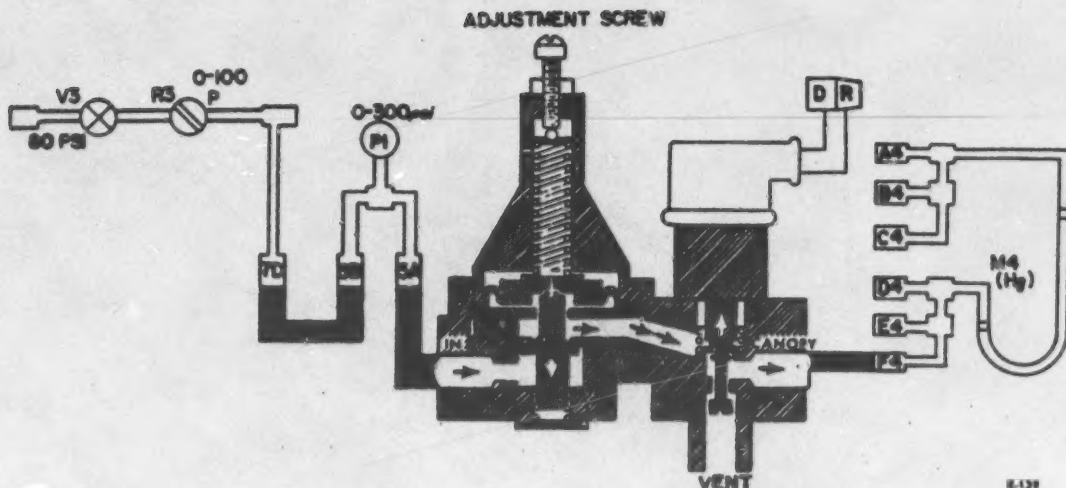


Figure 1.

d. Remove the plug from the vent port of the valve. Then have your instructor check your hookup before continuing.

e. Place the M4 manometer to the pounds and tenths scale. This scale begins with zero.

f. Place switch S1 in the "ON" position. DC voltmeter will read 25 ± 5 volts. Switch S2 will remain in the "OFF" position.

g. Open valve V3 (counterclockwise).

h. Turn R3 clockwise until gage P1 reads 50 psi. At this point we are simulating the aircraft engine that is operating with the canopy open. The canopy seal regulator solenoid is deenergized leaving the canopy seal deflated.

i. Place switch S2 in position number 3. This energizes the canopy seal regulator solenoid or simulates closing of the canopy. If the regulator is adjusted correctly, manometer M4 will read 20 to 24 psi. This is the amount of pressure actually going inside the canopy seal. If the reading on manometer M4 is not between 20 to 24 psi you will have to adjust the canopy seal regulator. Adjustment procedures can be found on page 3, paragraph 8b, of the TO. Make any adjustments now if necessary. Refer to figure 1 in this workbook to find the adjustment screw. Have your instructor check your manometer reading.

j. Move switch S2 between position "3" and "OFF" several times. The "OFF" position will deenergize the solenoid letting the seal deflate and the manometer read zero. This is to check for a sticking solenoid.

2504

- k. Place switch S2 in the "OFF" position.
- l. Turn R2 counterclockwise until pressure gage P1 reads zero.
- m. Turn valve V3 clockwise until closed.
- n. Place switch S1 in the "OFF" position.
- o. Disconnect canopy seal regulator, install vent cap and return the valve to locker #2.
- p. Cap all air ports, plug all hoses, and return air hoses to bottom of trainer.
- q. Unplug the trainer and report to the instructor. Have him check your work area before you leave.

2505

PREPARE THE MAN



PROGRAMMED TEXT

3ABN42331-PT-315

Technical Training

Aircraft Environmental Systems Mechanic

PRESSURIZATION PRINCIPLES

30 September 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42231 Instructional System. The material contained herein has been validated using thirty 42010 students enrolled in the 3ABR42231 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 54 minutes to complete the text.

OBJECTIVES

Successful completion of this programmed text will enable the student to respond accurately to a minimum of 70% of the measurement questions on the following objectives.

1. Identify as either true or false statements that describe:
 - a. The purpose of a pressurization system.
 - b. Effects on the human body caused by the lack of pressurization at high altitudes.
 - c. The normal methods of controlling air flow in a pressurized compartment.
 - d. Terms appropriate to pressurization systems.
2. Match statements describing the function of sections of a pressure regulator with those sections.
3. Match components with statements that describe their functions.
4. Referring to a chart identify as true or false statements about cockpit and aircraft altitude.
5. Refer to a chart to determine aircraft altitude, differential pressure, and cabin altitude or pressure.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading each step, you are asked to complete a statement, match statements, or respond in some other way. Read the material and make your response as directed by the frame. DO NOT MARK IN THIS TEXT. After you have made your response, compare your answer with the correct answer found at the top of the next even numbered page. Should you respond incorrectly, reread the frame to clarify the information, then continue. If necessary, you may go back to check a fact or a principle, but do not skip ahead unless you are told to do so in the package.

Use this simple rule: READ—RESPOND—CONFIRM—ADVANCE.

You will not be graded on how fast you complete this material. You will be tested on what you have learned.

Supersedes 3ABR42231-PT-315, 31 May 1973.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 2

As long as a pilot flies close to sea level (where he was designed to be), atmospheric pressure will force nitrogen, oxygen and other gases into his lungs and throughout his body. He needs the right amount of these gases to function. He needs them to live. However, as a plane gains altitude, atmospheric pressure goes down. The pilot gets to a point in his flight where there is not enough pressure. Low atmospheric pressure will not force the gases he needs through his system and his body will fail. Now he is faced with a real problem. At high altitudes his body functions become so affected that he has periods of dizziness, muscular weakness and at times severe pain.

Lack of oxygen can cause poor vision, increased heartbeat, dizziness, and muscle fatigue. Any of the symptoms are known as hypoxia.

Nitrogen starts to bubble at very low pressure. The bubbles, as they pass through the body, cause much pain in the muscles and joints. This symptom is known as the "bends." The bubbles in the blood that pass through the chest area cause difficulty in breathing. This is known as the "chokes." As the bubbles work their way through body tissues, skin blotches and itching occur and this is called the "creeps."

So, it is not a matter of what IS there at high altitudes that does cause discomfort, but rather, what is NOT there. And the important thing that is not there, is atmospheric pressure. To fix this problem, aircraft crew compartments (cabin, cockpit) have been pressurized.

Answer the statements as true (T) or false (F).

1. High altitudes have no effect on the human body.
2. Atmospheric pressure is needed to force the necessary gases through the body.
3. As altitude is decreased, atmospheric pressure is increased.
4. Oxygen begins to bubble at a very low pressure.
5. The "bends" is caused by lack of nitrogen.
6. The absence of nitrogen and oxygen at high altitudes is what causes the body to fail.
7. If man is to fly and function at high altitudes, he must stay within a pressurized compartment.
8. The terms crew compartment, cockpit, and cabin, have the same meaning.

2508

CORRECT RESPONSES TO FRAME 1: 1. F 2. T 3. T 4. F
 5. B 6. F 7. T 8. T

Frame 2

To help you see the relationship between atmospheric pressure and altitude, table 1 was made. You can see that an increase in altitude will result in a decrease in atmospheric pressure. The chart is a simplified version of a more complicated technical order chart.

<u>Altitude</u>	<u>ATM PRES (PSIA)</u>	<u>Altitude</u>	<u>ATM PRES (PSIA)</u>	<u>Altitude</u>	<u>ATM PRES (PSIA)</u>
-1,000	15.23	21,000	6.48	43,000	2.36
Sea Level	14.69	22,000	6.21	44,000	2.25
1,000	14.17	23,000	5.95	45,000	2.15
2,000	13.66	24,000	5.70	46,000	2.05
3,000	13.17	25,000	5.46	47,000	1.95
4,000	12.69	26,000	5.22	48,000	1.86
5,000	12.23	27,000	5.00	49,000	1.77
6,000	11.77	28,000	4.78	50,000	1.70
7,000	11.34	29,000	4.57	51,000	1.61
8,000	10.91	30,000	4.37	52,000	1.54
9,000	10.50	31,000	4.18	53,000	1.46
10,000	10.10	32,000	3.99	54,000	1.39
11,000	9.72	33,000	3.81	55,000	1.33
12,000	9.34	34,000	3.63	56,000	1.27
13,000	8.99	35,000	3.47	57,000	1.21
14,000	8.63	36,000	3.30	58,000	1.15
15,000	8.29	37,000	3.15	59,000	1.10
16,000	7.96	38,000	3.00	60,000	1.05
17,000	7.65	39,000	2.86	70,000	.648
18,000	7.34	40,000	2.73	80,000	.404
19,000	7.05	41,000	2.60	90,000	.252
20,000	6.76	42,000	2.48	100,000	.160

Table 1. Relation Between Altitude and Atmospheric Pressure.

Using table 1 and the response sheet, fill in the blanks showing atmospheric pressure at various altitudes.

1. _____ sea level.
2. _____ 12,000 ft.
3. _____ 25,000 ft.
4. _____ 50,000 ft.
5. _____ 100,000 ft.

At what altitude would the aircraft be if atmospheric pressure is:

6. 8.99 psi _____.
7. 6.76 psi _____.
8. 2.60 psi _____.
9. 1.05 psi _____.
10. .252 psi _____.

676

We now know that the aircraft cabin must be pressurized for high altitude flying. Let us find out where we get the pressure. Is the cabin pressurized by some sort of air compressor before flight? Do the crew members take bottles of air pressure with them? Is there a system on the plane that makes the pressure? All of these ideas could be right. A system on the aircraft is felt to be the best method of pressurizing.

Most planes that fly at great heights are run by jet engines. The engine compressor section supplies air pressure for operation of various systems on the plane. One of the systems that is run by engine bleed air (EBA), from the engine compressor section, is the air conditioning system. This system, in turn, supplies a flow of air to heat, cool, and pressurize the cabin. So, if the air conditioning system fails, cabin pressurization will be lost.

Answer the statements as true (T) or false (F).

1. Most aircraft that fly at high altitudes are jet powered.
2. The compressor section is a feature of a jet engine.
3. The air conditioning system is driven by air from the engine compressor section.
4. The air conditioning system supplies air for cabin pressurization.
5. Failure of the air conditioning system will have no effect on cabin pressurization.

2510

CORRECT RESPONSES TO FRAME 2: 1. 14.69 2. 9.34 3. 5.46 4. 1.70
5. .160 6. 13,000 7. 20,000 8. 41,000 9. 60,000 10. 90,000

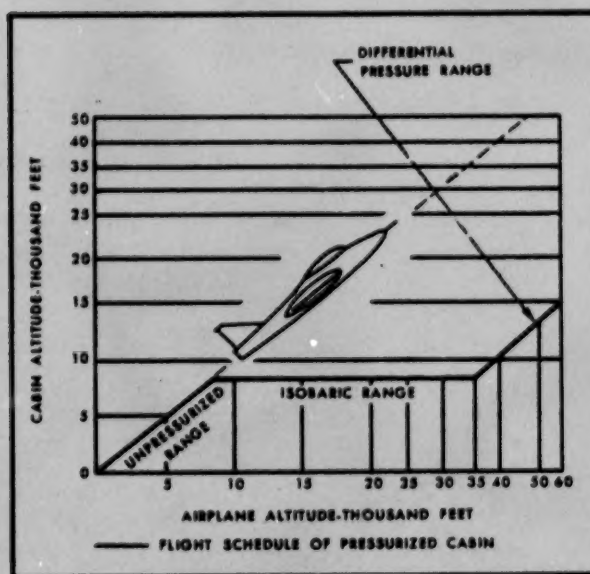
CORRECT RESPONSES TO FRAME 3: 1. T 2. T 3. T 4. T 5. F

Frame 4

You must be familiar with some terms used with cabin pressurization. The terms defined below will be used in your training on pressurization principles. It is important that you learn the meaning of each term. If you do not, the rest of this text and others to follow will be hard for you to understand.

1. PSIG - Pounds per square inch gage. The pressure shown on a gage. Does not include atmospheric pressure.
2. PSIA - Pounds per square inch absolute, in reference to zero. To find PSIA, take the pressure shown on a gage and add the atmospheric pressure to it.
3. PSID - Pounds per square inch differential. This is the difference in two pressures. For example: cabin pressure is 12 PSIA and atmospheric pressure is 9 PSIA. The PSID is 3 PSI.
4. Engine Bleed Air (EBA) - This is the supply of air that comes from the engine compressor section. The engine bleed air drives the air conditioning system.
5. Atmospheric Pressure - The pressure of the air mass surrounding the earth. At sea level this pressure is approximately 14.7 psi and it decreases as altitude increases.
6. Cabin Pressure - The amount of air pressure inside the aircraft cabin or crew compartment.
7. Aircraft Altitude - The exact height at which the aircraft is located. Measured in feet from sea level up. This altitude can be found if you know the cabin altitude and the differential pressure. Here is how it works: the cabin altitude is 20,000 feet, that is equal to a pressure of 6.76 psia. The differential pressure is 4.0 psid. You know that 4.0 psid means that the pressure in the cabin is 4.0 psi more than the atmospheric pressure. You would then subtract 4.0 psid from 6.76 psia, that leaves 2.76 psia. This is the atmospheric pressure. The 2.76 psia is equal to an altitude of approximately 40,000 feet, the aircraft altitude.

8. **Cabin Altitude** - A comparison of cabin pressure to atmospheric pressure at various altitudes. This altitude can be found if you know the aircraft altitude and the differential pressure. For example: Let us say, the aircraft altitude is 50,000 feet, that is equal to a pressure of 1.7 psia. The differential pressure is 5.0 psid. In this case, you would have to add 5.0 psid to 1.7 psia. 5.0 psia plus 1.7 psia is equal to 6.7 psia. The 6.7 psia is equal to a cabin altitude of approximately 20,000 feet.
9. **Isobaric Range** - Two points in cabin altitude between which cabin pressure remains constant. One point is where cabin pressurization begins and the other point is where the constant pressure ends and differential pressure takes over. See figure 1. Notice that there are three ranges of cabin pressurization.



PRESSURIZATION SCHEDULE

N-453

Figure 1.

10. **Aneroid or Evacuated Bellows** - A metallic bellows from which all air has been removed. It is sealed so no pressure can get in or out. The aneroid is sensitive to changes in atmospheric pressure. The aneroid reacts to atmospheric pressure above

and below 10 psi. A guide spring inside the aneroid sets this pressure. When atmospheric pressure is above 10 psi the aneroid will contract. When atmospheric pressure is below 10 psi the aneroid will expand.

11. Low Differential - A feature of certain cabin pressure regulators which maintains a low pressure differential between the cabin pressure and atmospheric pressure while the aircraft is in a combat area.
12. High Differential - A feature of some cabin pressure regulators which maintains a high pressure differential between cabin pressure and atmospheric pressure. Usually found on noncombat type aircraft.

Answer the statements as either true (T) or false (F).

1. Engine bleed air comes from the engine exhaust section.
2. PSJD is gage pressure plus atmospheric pressure.
3. Cabin altitude has to be the same as aircraft altitude.
4. Aneroid bellows are filled with air and expand under high pressure.
5. During the isobaric range cabin pressure remains constant.

The air conditioning system always pumps air into the cabin. Pressurization will get too high if some sort of control is not used.



N-454

Figure 2.

There is one type of control which is built in. This is what is known as normal leakage. Even though the cabin is sealed, some air still can get out around cables, fittings, and joints in the metal panels. This leakage is not enough to stop overpressurization. The air conditioning system puts out a greater flow of air than the normal leakage can take care of.

In addition to normal leakage, most planes use a device known as a cabin pressure regulator. This unit is put in the aircraft cabin and it vents to the outside (atmosphere). Its function is simple. When cabin pressure gets too low (minimum), the regulator will close the vent to the outside. This will allow the air conditioning system to build up the pressure. If pressure starts to go too high (maximum), the regulator will open the vent. Excessive pressure is dumped into the atmosphere.

Answer the statements as true (T) or false (F).

1. Cabin pressure is supplied by the air conditioning system.
2. All aircraft cabins have a certain amount of normal leakage.
3. Normal leakage cannot effectively control cabin pressure.
4. The cabin pressure regulator is actuated by cabin air temperature.
5. The cabin pressure regulator is located inside the aircraft cabin.

2514

CORRECT RESPONSES TO FRAME 4: 1. F 2. F 3. F 4. F 5. T

CORRECT RESPONSES TO FRAME 5: 1. T 2. T 3. T 4. F 5. T

Frame 6

You now have a general idea of what a cabin pressure regulator does. Let us take a close look to see just how one works. There are several types of regulators and some of them are complicated. All of them are made to automatically control cabin pressure. By controlling pressure, the plane can fly at various altitudes and the pilot or flight crew will not have any discomfort due to improper pressurization.

Most regulators have two main parts; (1) the regulator, and (2) the outflow valve. These two parts are sometimes put together as one unit or they may be mounted in different places in the cabin and connected by air lines (tubing).

Answer the statements as true (T) or false (F).

1. There are several types of cabin pressure regulator assemblies.
2. Cabin pressure regulator assemblies automatically control cabin pressure.
3. Most regulator assemblies are made up of only one main part.
4. The regulator and outflow valve must be mounted at separate locations in the cabin.
5. The regulator and outflow valve may be bolted together as one unit.

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The regulator assembly is installed INSIDE the cabin. The outflow valve covers an opening in the aircraft skin. When the outflow valve is open, cabin air can flow out to the atmosphere. Refer to figure 3 as we talk about the outflow valve.

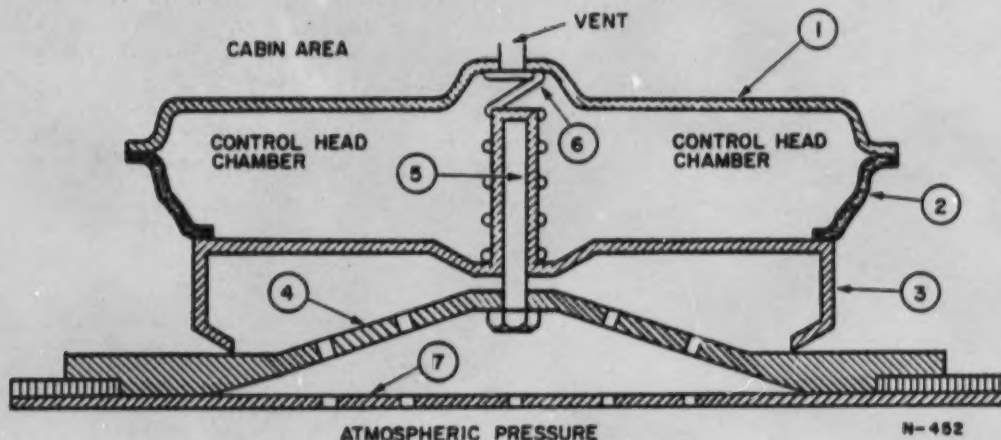


Figure 3.

In figure 3 the round outflow valve has been cut in half from top to bottom and you are looking into the open side of one half. Number one (1) is part of the valve housing. It bolts to the regulator (not shown) and does not move. Number two (2) is a rubberized diaphragm that allows the valve to move. Number three (3) is the valve (shown closed) and it moves up and down. Number four (4) is the lower part of the valve housing that bolts to the inside of the aircraft skin. Number five (5) is a guide bolt on which the valve slides up and down. Number six (6) is a spring which pushes down on the valve with about .3 pounds of force to help keep the valve on seat. Number seven (7) is the aircraft skin that has slits cut so that cabin pressure may vent to the atmosphere.

From the illustration, identify the name of each part of the outflow valve.

- | | |
|----------------------------|----------------------------|
| ___ a. guide bolt. | ___ e. valve |
| ___ b. upper valve housing | ___ f. aircraft skin |
| ___ c. diaphragm | ___ g. lower valve housing |
| ___ d. spring | |

2516

CORRECT RESPONSES TO FRAME 6: 1. T 2. T 3. F 4. F 5. TCORRECT RESPONSES TO FRAME 7: a. 5 b. 1 c. 2 d. 6 e. 3f. 7 g. 4

Frame 8

When the plane is on the ground and the air conditioning system is off, cabin pressure and atmospheric pressure are both at 14.7 psi. The spring in the outflow valve will push down with a force of 0.3 pounds. This force plus the atmospheric pressure that comes in the control head chamber through the vent line, holds the outflow valve on seat. Total pressure is 15 psia ($14.7 + 0.3$). Cabin pressure (14.7 psia) does push up on the valve, but can not overcome the downward force of 15 psia.

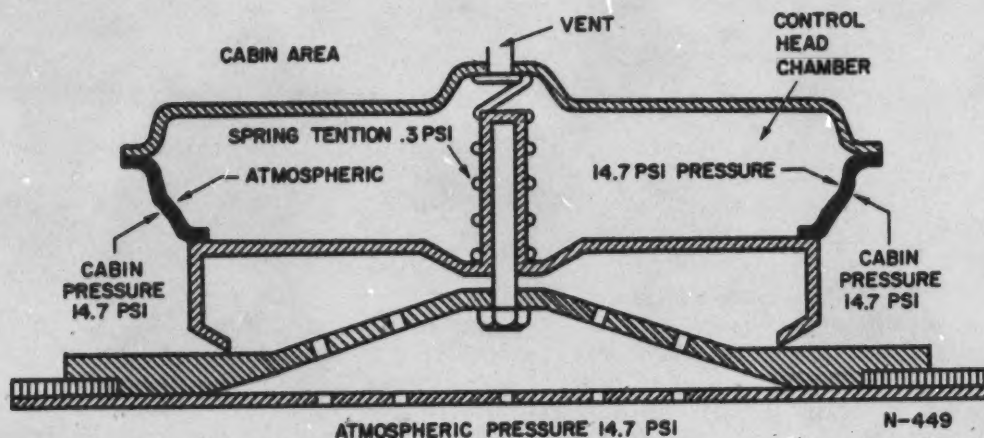


Figure 4.

NO RESPONSE REQUIRED

Before going any further, let's briefly review what has been covered thus far.

1. Cabin pressurization is needed for aircraft that fly at high altitudes.
2. Cabin pressurization is provided by the air conditioning system.
3. The air conditioning system is driven by air pressure from the engine compressor section.
4. Cabin pressure must be controlled to prevent it from becoming excessive. The most common control device used to control pressure is the cabin pressure regulator assembly.
5. The regulator assembly is always located inside the pressurized compartment (cabin).
6. The regulator assembly is made of two major parts, the outflow valve and the regulator.
7. The outflow valve opens and closes to allow cabin pressure to build up or be vented through louvers in the aircraft skin to the atmosphere.
8. Control head pressure is atmospheric pressure plus spring tension. This pressure tries to hold the outflow valve on seat.
9. Should cabin pressure exceed control head pressure it will offseat the outflow valve.

NO RESPONSE REQUIRED

2518

CORRECT RESPONSES TO FRAME 8: None required.

CORRECT RESPONSE TO FRAME 9: None required.

Frame 10

The next part of the cabin pressure regulator assembly is the regulator. The type we will discuss sits on top of the outflow valve. The control head chamber of the outflow valve vents to the atmosphere through the regulator control head chamber.

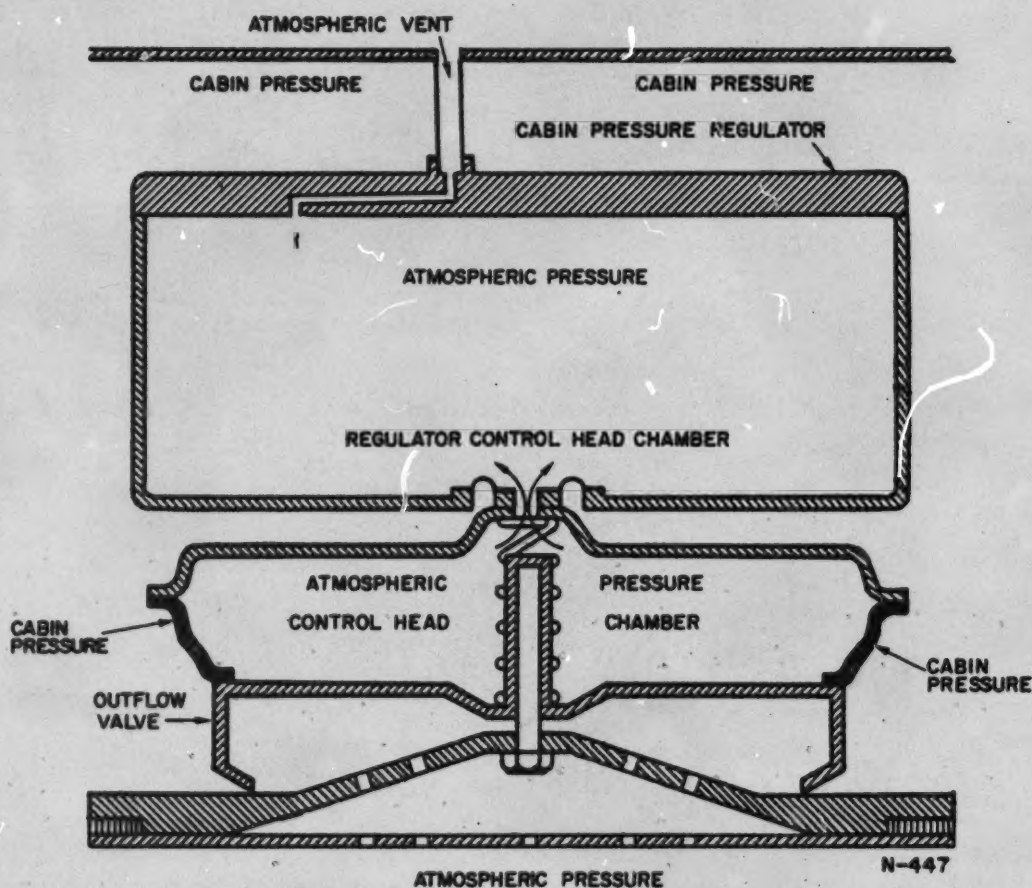


Figure 5.

The position of the outflow valve is

- a. Open.
- b. Closed.

686

A filter and orifice have been added to the illustration. The orifice (bleed hole) is put in the control head of the regulator to let a small amount of cabin air flow in the control head of the regulator. The filter is used to keep dirt from plugging the orifice. Compare the size of the orifice with the atmospheric vent. The orifice is made smaller. Air can flow out through the vent faster than it can enter the control head through the orifice.

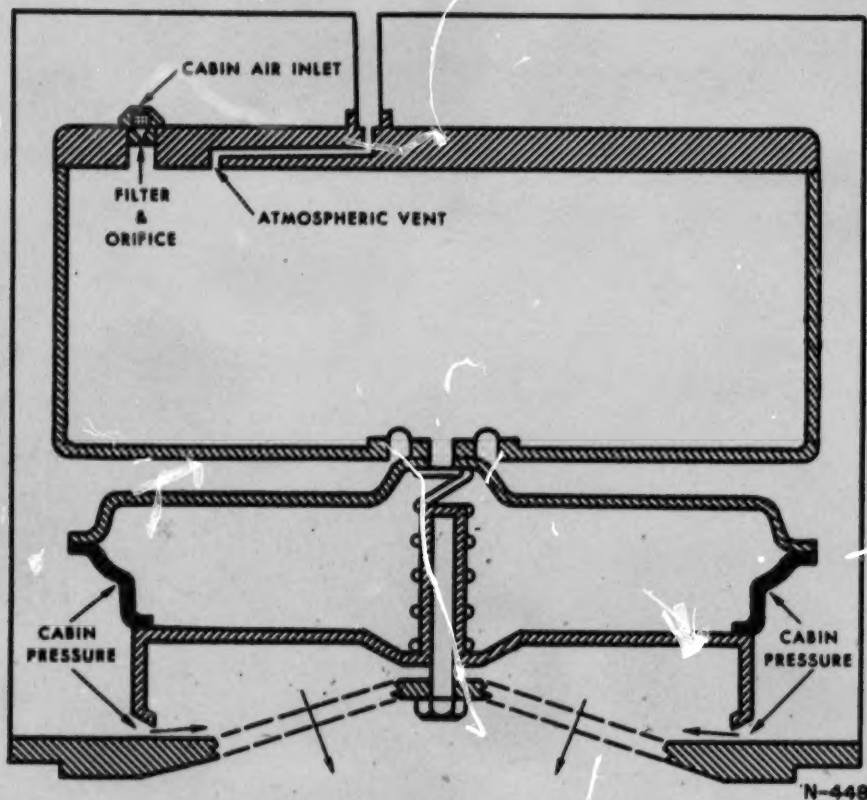


Figure 6.

2520

CORRECT RESPONSES TO FRAME 10: b

Frame 11 (Cont'd)

Answer the statements as true (T) or false (F).

1. Due to the size of the orifice, the pressure in the control head chamber will be relieved faster than it can be built up.
2. Reducing the control head pressure faster than it can be built up will let the cabin pressure open the outflow valve.
3. If the filter became clogged with dirt, the control head chamber pressure would reduce and the outflow valve would open.
4. Opening the outflow valve would reduce the cabin pressure by allowing the cabin air pressure to flow to the atmosphere.

688

Identify each part of the pressure regulator and outflow valve.

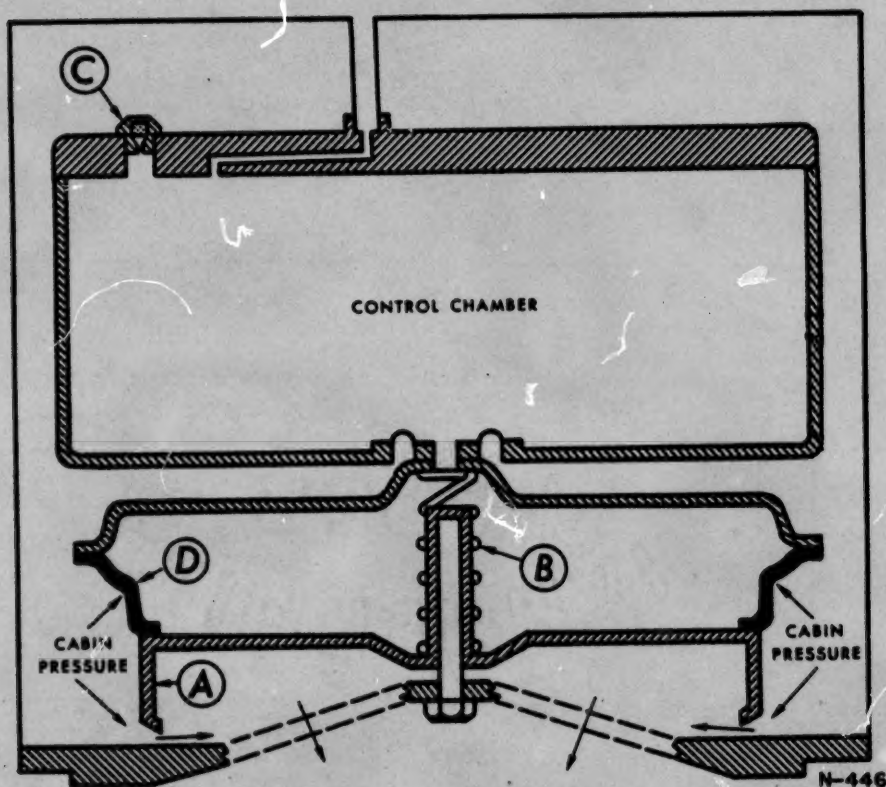


Figure 7.

1. A thin flexible disc attached to the outflow valve that separates cabin pressure from control head pressure.
2. Causes movement of the outflow valve.
3. Applies a pressure of .2 to .3 psi to the outflow valve to keep the outflow valve from chattering during its opening and closing cycles.
4. Controls the size of the opening in the aircraft skin.
5. Controls the amount of cabin pressure air flowing to the atmosphere.
6. Allows a metered amount of cabin air pressure to enter the control head of the cabin pressure regulator and prevents dirt from plugging or restricting the orifice.

2522

CORRECT RESPONSES TO FRAME 11: 1. T 2. T 3. T 4. T

CORRECT RESPONSES TO FRAME 12: 1. D 2. D 3. B 4. A 5. A
6. C

Frame 13

The illustration shows that an aneroid, lever, fulcrum, and metering valve have been added. The spring tries to open the metering valve. In Frame 4 you were taught what an aneroid is and how it works.

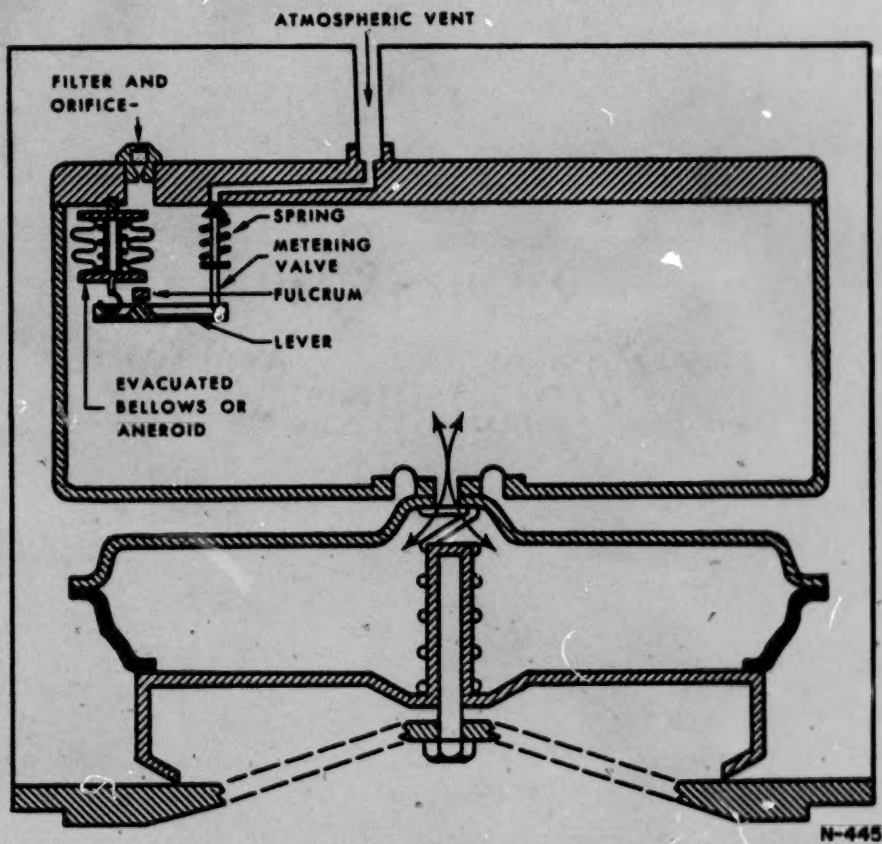


Figure 8.

NO RESPONSE REQUIRED

690

In the illustration, a spring has been hooked to the lever. One end of the spring is threaded onto a bolt. Turning the bolt adjusts the spring tension. This adjustment sets the altitude at which the aneroid will close the metering valve.

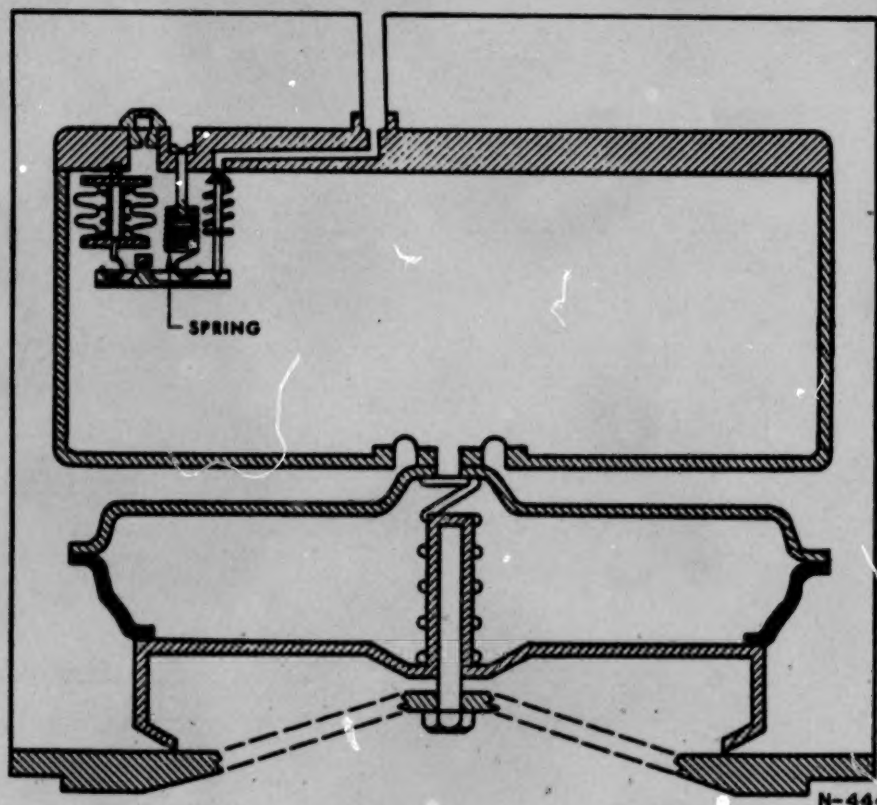


Figure 9.

Answer the statements as true (T) or false (F).

1. Spring tension tends to close the metering valve by pulling up on the lever.
2. Adjusting the spring tension determines the altitude at which the metering valve will close.
3. Compressing the aneroid closes the metering valve.

2524

CORRECT RESPONSES TO FRAME 13: None required.

CORRECT RESPONSES TO FRAME 14: 1. T 2. T 3. F

Frame 15

When the aneroid contracts (low altitude, high pressure) it pulls up on the lever and offseats the metering valve. This will let control head pressure in the regulator and outflow valve escape into the atmosphere. As control head pressure drops, the cabin pressure on the outside of the outflow valve will force the valve open. Air can then flow out the opening in the aircraft skin. This will cause a drop in cabin pressure. You can see that the aneroid has compressed, spring tension has been overcome and the metering valve has opened.

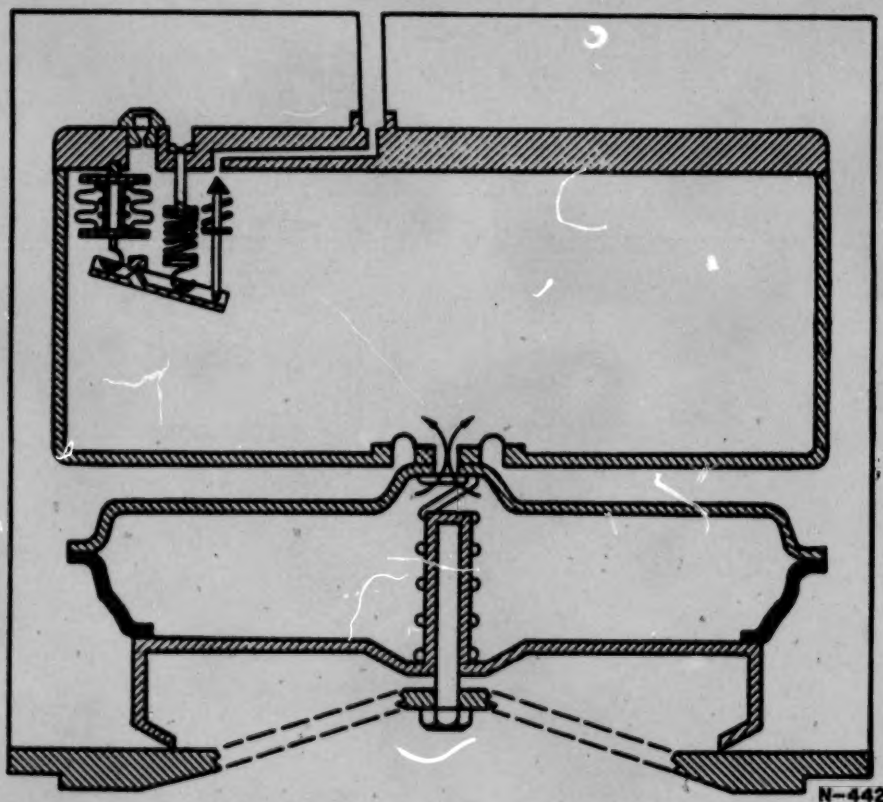


Figure 10

Identify the statement that best describes the events that will occur following the opening of the metering valve.

a. The control head chamber pressure in both the regulator and the outflow valve will bleed to atmosphere. Pressure in the control head chamber of the outflow valve is reduced. The cabin pressure surrounding the outflow valve diaphragm will force the outflow valve open. Cabin pressure is drained to the atmosphere.

b. Control head pressure in both the regulator and the outflow valve will build up. The pressure in the control head chamber of the outflow valve increases. The control head pressure in the outflow valve is higher than the cabin pressure surrounding the outflow valve. The outflow valve will close and allow cabin pressure to build up.

2526

CORRECT RESPONSES TO FRAME 15: a

Frame 16

In the illustration shown below, the aneroid has expanded and the spring has moved the metering valve to the closed position.

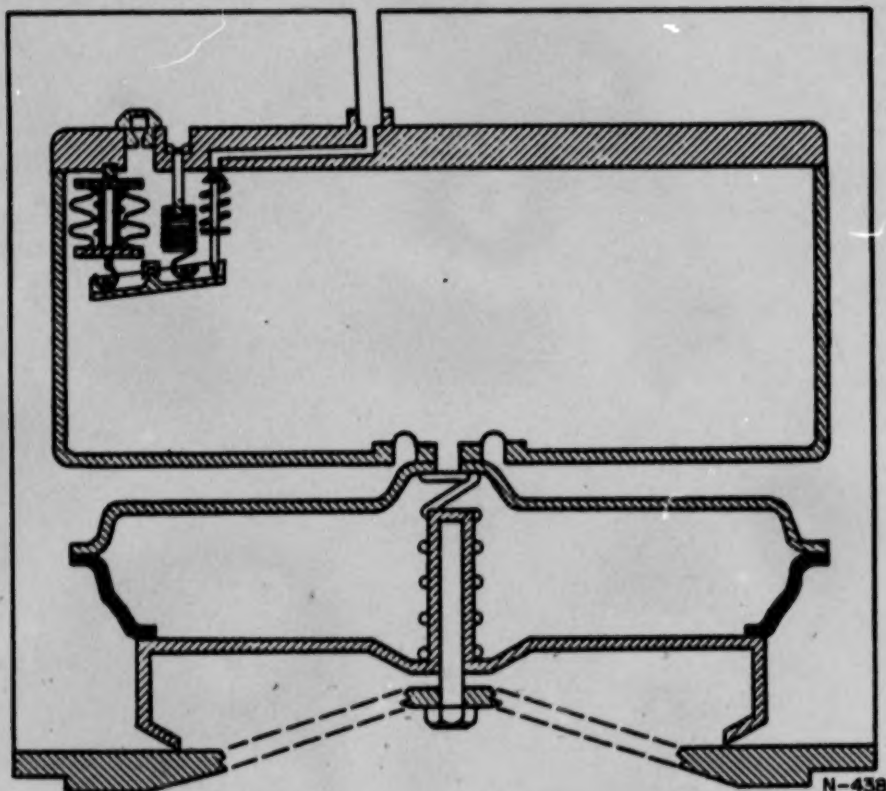


Figure 11.

Identify the statement that best describes the events that take place following the closing of the metering valve.

a. The control head chamber pressure in both the regulator and the outflow valve bleeds to atmosphere. Pressure in the control head chamber of the outflow valve is reduced. The cabin pressure surrounding the outflow valve diaphragm forces the outflow valve open. Cabin pressure is drained to the atmosphere.

b. The control head pressure in both the regulator and the outflow valve builds up. Pressure in the control head chamber of the outflow valve is increased. Since the control head pressure in the outflow valve is higher than the cabin pressure surrounding it, the outflow valve closes. Cabin pressure is allowed to build up.

The isobaric section is made up of the aneroid, spring, and metering valve. It does two things. It keeps the cabin from being pressurized until the plane gets to a preset height. Then it lets the cabin be pressurized but keeps the amount of pressure steady until the plane gets to a higher altitude. Go back to Frame 4 and look at figure 1. You will see three ranges of cabin pressurization; (1) unpressurized, (2) isobaric, and (3) differential. The isobaric section controls the first two of these.

Answer the statements as true (T) or false (F).

1. The isobaric section consists of an aneroid, an adjustable spring, and a metering valve.
2. The range of cabin pressurization at which a constant value is maintained is called the differential range.
3. There are at least three ranges in a cabin pressurization system.
4. The isobaric section of the cabin pressure regulator produces the first two ranges of cabin pressurization.

2528

CORRECT RESPONSES TO FRAME 16: b

CORRECT RESPONSES TO FRAME 17: 1. T 2. F 3. T 4. T

Frame 18

The differential section is one of the main parts of a cabin pressure regulator. Its job is to take over control of cabin pressure when the isobaric section kicks out. In figure 1 (Frame 4) you can see that the isobaric range ends at 35,000 ft. When the differential section takes over it keeps a set differential between cabin and atmospheric pressure. The differential section is made up of just a few parts. One of them is the metering valve shown below.

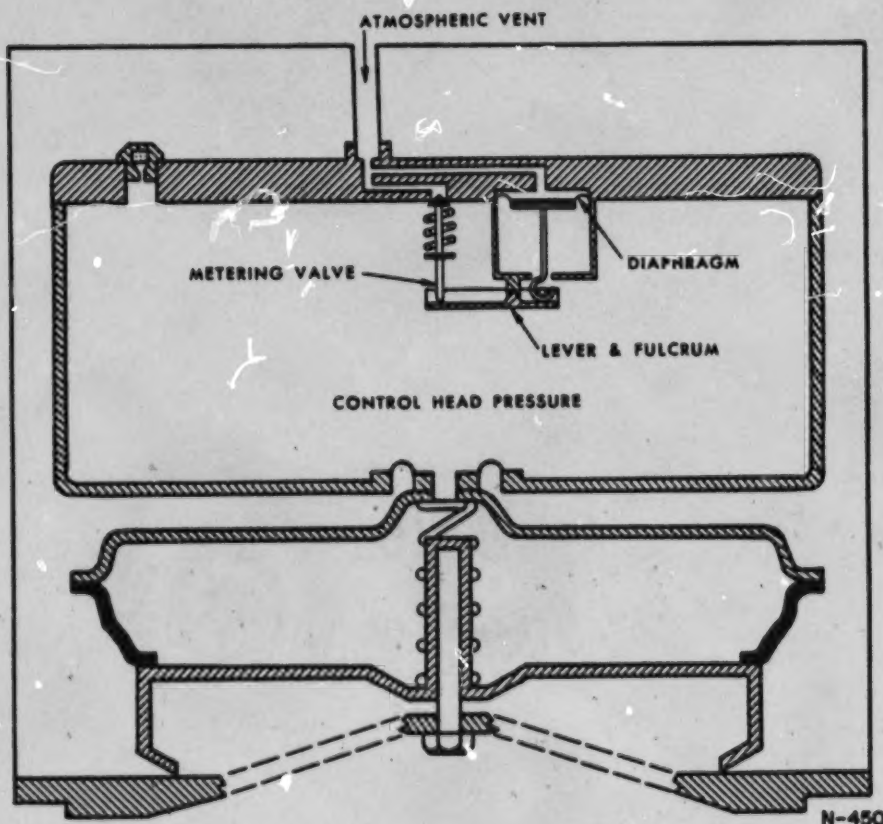


Figure 12.

The metering valve is moved on seat or off seat by the lever. The lever rocks up and down on a fulcrum (pivot point). The lever is moved by a piston which separates control head pressure from the vent port. The piston is moved up and down by a diaphragm. The diaphragm is pushed up or down by control head or atmospheric pressure whichever is greater.

Answer the statements as true (T) or false (F).

1. If the control pressure is higher than the atmospheric pressure, the diaphragm is forced up and the metering valve opens.
2. If atmospheric pressure is greater than control pressure, the diaphragm is forced down and the metering valve closes.
3. Opening the metering valve reduces control pressure so that the outflow valve may be opened.
4. Closing of the metering valve causes control chamber pressure to build up and close the outflow valve. Opening the metering valve causes control chamber pressure to decrease and allow the outflow valve to be opened.
5. Closing the metering valve decreases control chamber pressure and opens the outflow valve. Opening the metering valve increases control chamber pressure and closes the outflow valve.

2530

CORRECT RESPONSES TO FRAME 18: 1. T 2. F 3. T 4. T 5. F

Frame 19

You can see in the illustration that a spring has been hooked to the lever. This spring, along with the atmospheric pressure pushing down on the diaphragm and piston, tries to keep the metering valve on seat. The spring is adjustable and should be set to keep a 5 psi differential between cabin and atmospheric pressures.

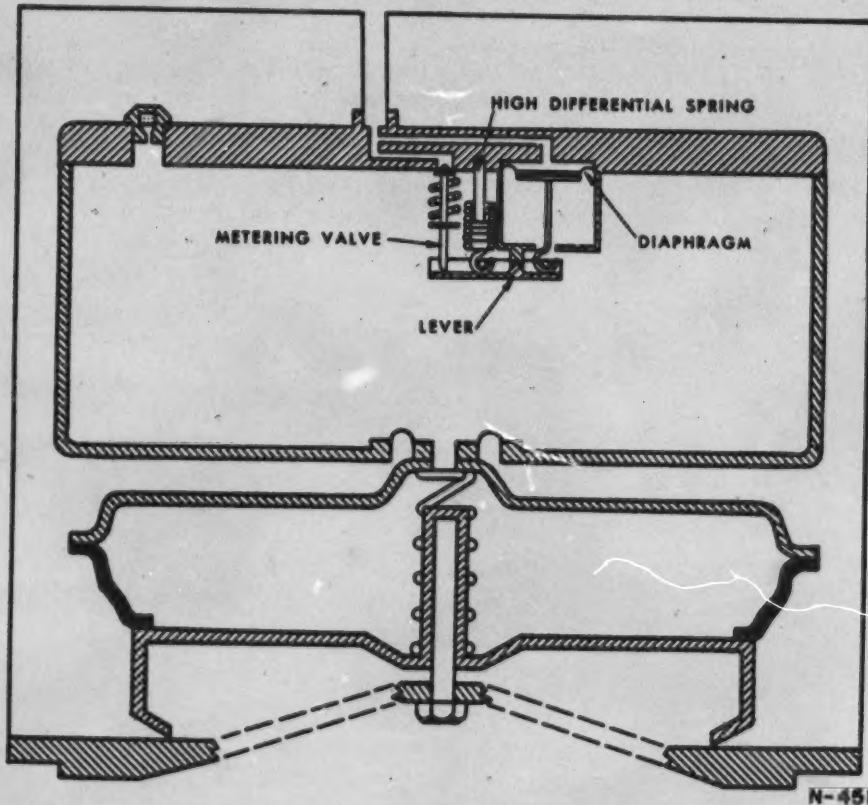
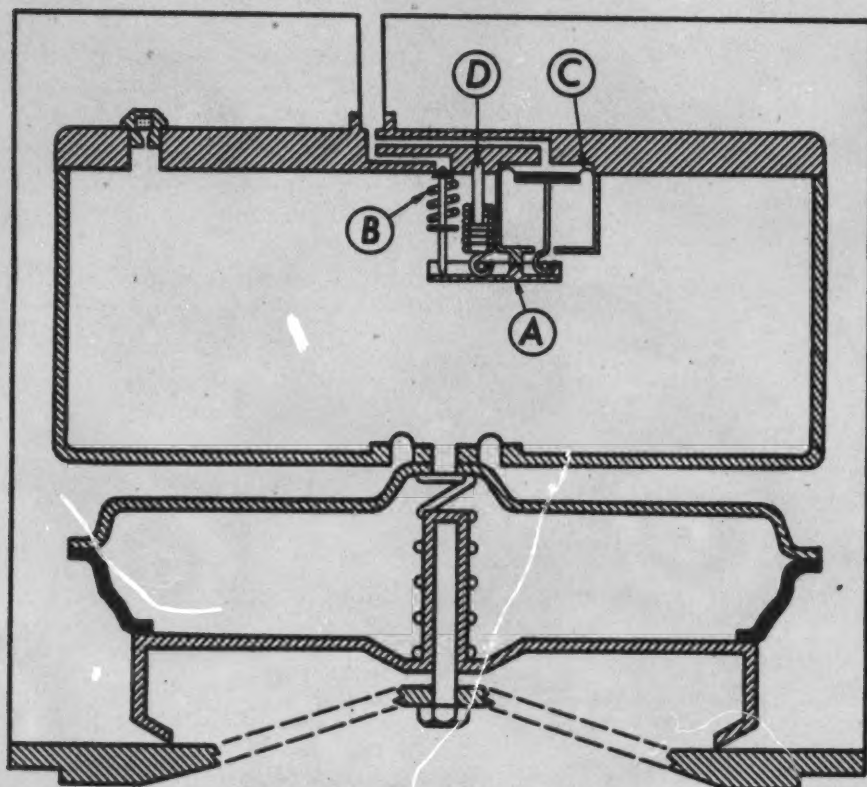


Figure 13.

Identify the statement which best describes the operation of the differential section.

- a. To open the metering valve, control chamber pressure must be greater than the combined force of the differential spring and atmospheric pressure.
- b. To open the metering valve, the combined force of the atmospheric pressure and spring tension must be greater than the control head chamber pressure.

Identify each part of the differential section.



N-439

Figure 14.

1. Controls the amount of chamber pressure that bleeds to atmosphere thereby controlling the opening and closing of the outflow valve.
2. Separates atmospheric pressure from control head pressure.
3. Links the differential diaphragm and metering valve together so that the diaphragm can control the position of the metering valve.
4. Works with the atmospheric pressure on the top of the differential diaphragm to close the metering valve.

2532

CORRECT RESPONSES TO FRAME 19: a

CORRECT RESPONSES TO FRAME 20: 1. D 2. C 3. A 4. B

Frame 21

Identify each part of the cabin pressure regulator and outflow valve.

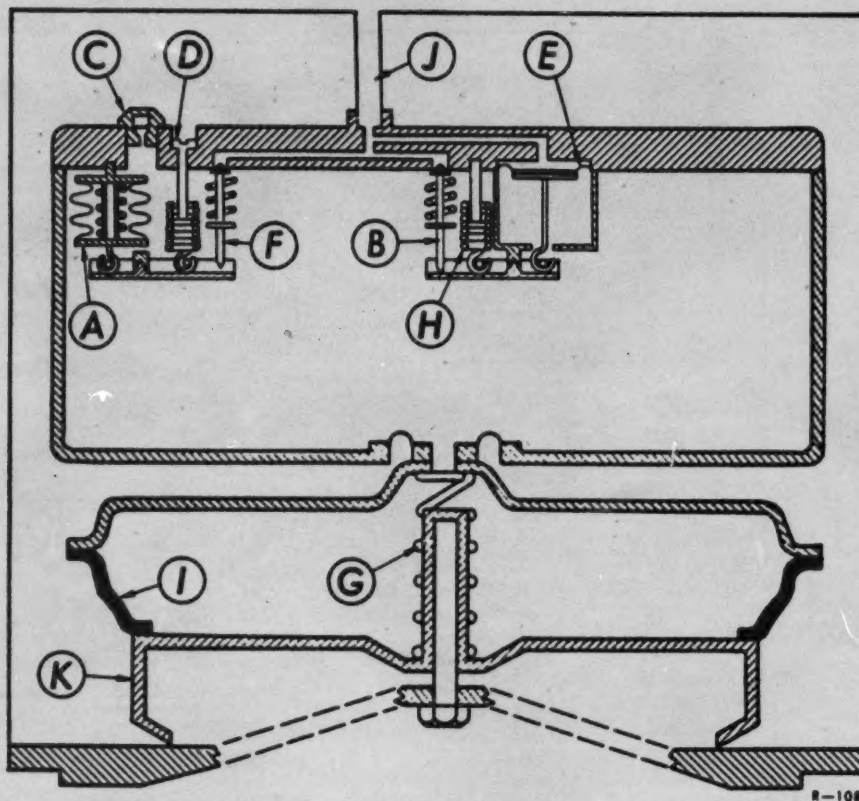


Figure 15.

1. Helps supply the force which tends to keep the outflow valve on seat.
2. Opens and closes to vent cabin pressure to the atmosphere.
3. Separates outflow valve control head pressure from cabin pressure.
4. Allows a small amount of cabin air pressure to enter the regulator control head chamber.
5. Aids the aneroid in applying the force to close the metering valve.
6. Vents control head pressure to the atmosphere when the aneroid is compressed.
7. Vents control head pressure to the atmosphere during operation of the differential section.

8. Is actuated by either control head pressure or atmospheric pressure.
9. Expands or contracts depending on aircraft altitude.
10. Aids the diaphragm and piston in positioning the differential metering valve.

2534

CORRECT RESPONSES TO FRAME 21: 1. G 2. K 3. I 4. C
5. D 6. F 7. E 8. K
9. A 10. H

Frame 22

Now let's take everything we've talked about and put it all together as an operational system. Refer to foldout 1.

UNPRESSURIZED RANGE

1. Aircraft on the ground - The air conditioning is on. Cabin pressure builds up both inside and outside the regulator. It gets inside the regulator through the filter and orifice and collapses the aneroid. This pulls the isobaric metering valve off seat and vents both control head chambers to the atmosphere. Now the pressure on the outside pushes up on the outflow valve diaphragm and lifts the outflow valve off seat. This lets cabin pressure be dumped and the plane is unpressurized.

2. Aircraft starts to climb - All components of the regulator are in the same position as when the aircraft was on the ground. Keep in mind that both control head chambers are vented to the atmosphere. Atmospheric pressure is decreasing as the aircraft climbs.

Answer the statements as true (T) or false (F).

1. At this time the aneroid is compressed.
2. The isobaric metering valve is off seat.
3. Both control head chambers are vented to the atmosphere through the isobaric metering valve.
4. Cabin pressure is building up on the outside of the regulator faster than it can bleed through the orifice into the control head chamber.
5. The outflow valve is off seat.
6. The cabin is not pressurized while the aircraft is on the ground.
7. As the aircraft starts to climb, atmospheric pressure starts to decrease.

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ISOBARIC RANGE

1. Aircraft at 11,000 feet - By the time the aircraft has reached 11,000 feet, the atmospheric pressure has dropped to 9.72 psia (see table 1). Now the spring tension inside the aneroid (10 psia) is greater than the pressure in the control head chamber (9.72 psia). The aneroid expands to close the isobaric metering valve. As soon as the metering valve is closed, the outflow valve goes on seat. This is because the pressure inside the control head chambers overcomes the cabin pressure that had been dumped through the outflow valve. Once the outflow valve goes on seat, cabin pressure will build up and bleed through the orifice. This will compress the aneroid (10 psia) and open the metering valve again.

2. Aircraft between 11,000 and 29,000 feet - Between these two heights the regulator keeps cycling (opening and closing). This keeps cabin pressure at 9.72 psia which is equal to the atmospheric pressure at 11,000 feet. This is called "cabin altitude." Cabin altitude means that the plane can fly at any height between 11,000 and 29,000 feet but cabin pressure will stay at the 11,000 ft. value. Keep in mind that all the time the plane is climbing, the pressure on top of the differential diaphragm is decreasing.

Answer the statements as true (T) or false (F).

1. During the isobaric range cabin pressure is at a constant value.
2. Cabin pressure is kept constant by the cycling (opening and closing) of the isobaric metering valve and the outflow valve.
3. While in the isobaric range, "cabin altitude" is equivalent to the atmospheric pressure at one altitude but the aircraft is usually at a higher altitude.
4. The isobaric range is between the point where pressurization begins and the point where the differential section takes over.

2536

CORRECT RESPONSES TO FRAME 22: 1. T 2. T 3. T 4. T 5. T
6. T 7. T

CORRECT RESPONSES TO FRAME 23: 1. T 2. T 3. T 4. T

Frame 24

DIFFERENTIAL RANGE

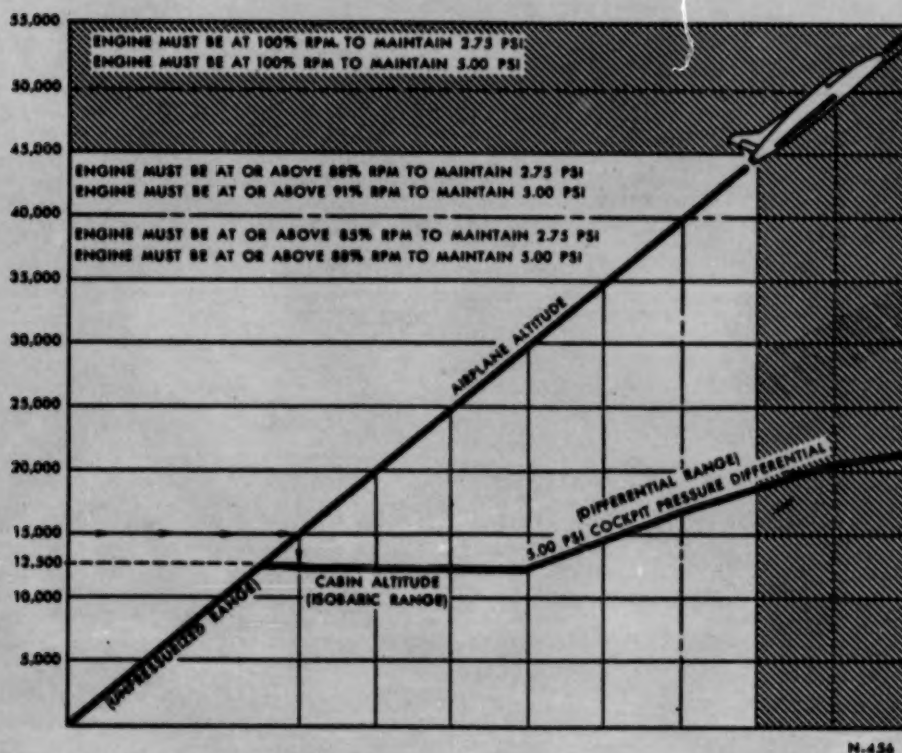
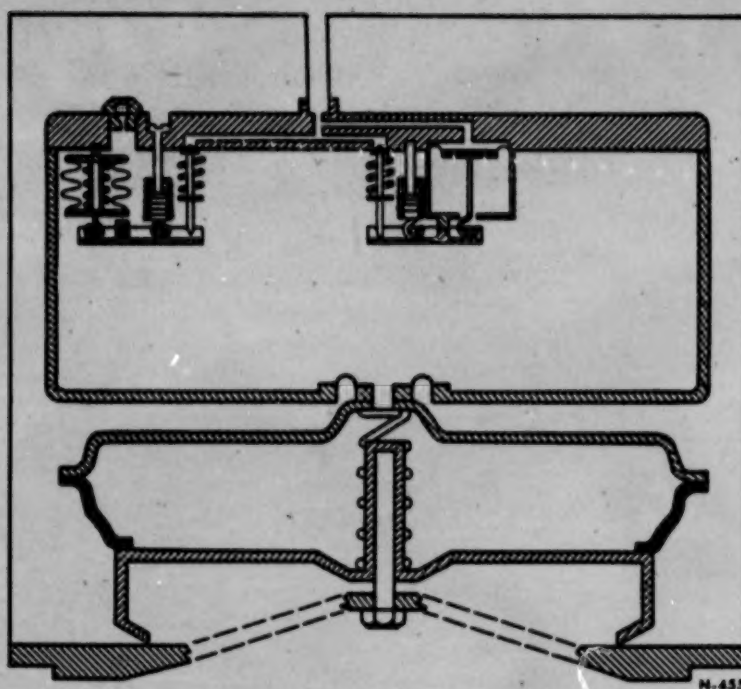
1. Aircraft at 29,000 feet - When the plane is at 29,000 feet atmospheric pressure on top of the differential diaphragm is down to 4.57 psia. In the control head chamber there is 9.72 psia, that is due to cabin air bleeding through the orifice. The isobaric metering valve can not come off seat since the aneroid has expanded due to its pressure (10 psia) being greater than control head chamber pressure (9.72 psia). The isobaric section is now ineffective so something else is going to have to control cabin pressure.

2. At this time, the differential metering valve is held on seat by 4.57 psia atmospheric pressure plus 5 pounds of spring tension. That makes a total of 9.57 psia. Control head chamber pressure is at 9.72 psia, so, the differential diaphragm is pushed up and pulls the differential metering valve off seat. Air in the control head can vent through the metering valve to the atmosphere. Cabin pressure will push the outflow valve off seat and excessive pressure will be dumped. When atmospheric pressure plus spring tension is greater than the decreasing control head pressure the metering valve will be forced on seat and the cycle starts over. With the differential section in control, cabin pressure will stay at 5 psi more than atmospheric pressure no matter how high the aircraft goes.

Answer the statements as true (T) or false (F).

1. The differential section takes over control of pressurization at the point where the isobaric section becomes ineffective.
2. Atmospheric pressure plus spring tension tries to hold the differential metering valve on seat.
3. The differential metering valve is forced off seat when control head chamber pressure exceeds atmospheric pressure by 5 psi.
4. The differential section keeps cabin pressure 5 psi greater than atmospheric pressure regardless of aircraft altitude.

CORRECT RESPONSES TO FRAME 24: 1. T 2. T 3. T 4. T



Foldout 1.

PRESSURIZATION PRINCIPLES

Frame 1	Frame 4 (Cont'd)	Frame 10	Frame 17 (Cont'd)	Frame 22
1. _____	4. _____	a. _____	2. _____	1. _____
2. _____	5. _____	b. _____	3. _____	2. _____
3. _____	Frame 5	Frame 11	4. _____	3. _____
4. _____	1. _____	1. _____	Frame 18	4. _____
5. _____	2. _____	2. _____	1. _____	5. _____
6. _____	3. _____	3. _____	2. _____	6. _____
7. _____	4. _____	4. _____	3. _____	7. _____
8. _____	5. _____	Frame 12	4. _____	Frame 23
Frame 2	Frame 6	1. _____	5. _____	1. _____
1. _____	1. _____	2. _____	Frame 19	2. _____
2. _____	2. _____	3. _____	a. _____	3. _____
3. _____	3. _____	4. _____	b. _____	4. _____
4. _____	4. _____	5. _____	Frame 20	Frame 24
5. _____	5. _____	6. _____	1. _____	1. _____
6. _____	Frame 7	Frame 13	2. _____	2. _____
7. _____	a. _____	None	3. _____	3. _____
8. _____	b. _____	Required	4. _____	4. _____
9. _____	c. _____	Frame 14	Frame 21	
10. _____	d. _____	1. _____	1. _____	
Frame 3	e. _____	2. _____	2. _____	
1. _____	f. _____	3. _____	3. _____	
2. _____	g. _____	Frame 15	4. _____	
3. _____	Frame 8	a. _____	5. _____	
4. _____	None	b. _____	6. _____	
5. _____	Required	Frame 16	7. _____	
Frame 4	Frame 9	a. _____	8. _____	
1. _____	None	b. _____	9. _____	
2. _____	Required	Frame 17	10. _____	
3. _____		1. _____		



Technical Training

Aircraft Environmental Systems Mechanic

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TAS - 150; TTVGC - 2

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42231 instructional system. The material contained herein has been validated using thirty 42010 students enrolled in the 3ABR42231 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 0.9 hour to complete the text.

OBJECTIVES

After completing this text each student will be able to describe the following areas with 70% accuracy.

1. Purpose of a pressurization system.
2. System components.
3. Sections of system components.
4. Function of each component.

INSTRUCTIONS

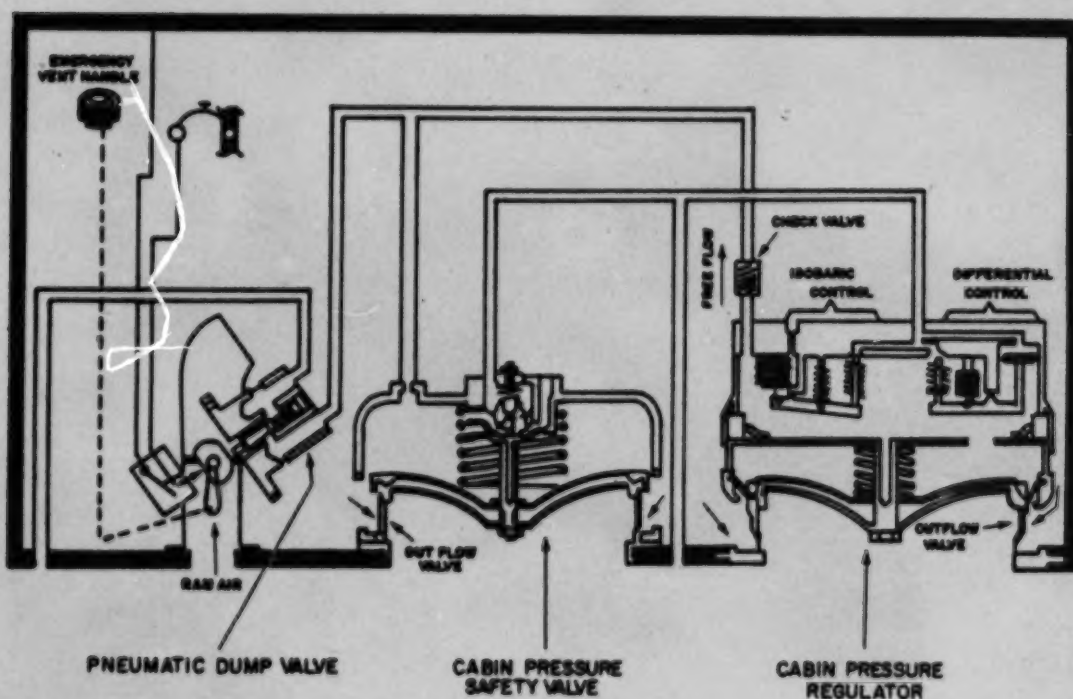
This package presents information in steps called "frames." After each step you are asked to choose a correct response by matching or telling if a statement is true (T) from a list of statements. Do not mark in the text. Use the reference sheet. Read each frame carefully and then select your answer. The correct answers will be found on the top of the next page. If you are right, proceed to the next frame. If you are wrong or in doubt, read the frame again.

The main reason for cabin pressurization is to make the air crew comfortable, while the aircraft is flying at high altitudes. The pressurization system is used to keep a differential pressure between the inside and outside of an aircraft. Most fighter aircraft pressurization systems have a pneumatic dump valve, a cabin pressure safety valve, a cabin pressure regulator, and an emergency vent handle.

Select the phrases that will complete the statement. Indicate your choice as true (T) or false (F).

A pressurization system provides crew comfort by

1. keeping a differential pressure between the inside and the outside of an aircraft.
2. keeping a constant pressure in the cabin regardless of altitude.
3. keeping cabin pressure at 14.7 psia.



N-436

Diagram 1.

2542

CORRECT RESPONSES TO FRAME 1: 1. T 2. F 3. F

Frame 2

The pressurization system is used to keep the cabin at a desired pressure, when the aircraft is flying. Pressure in the cabin is held in the proper range by controlling the amount of conditioned air that leaves the pressurized cabin.

Select the phrases that will complete the statement. Indicate your choice as true (T) or false (F).

A pressurization system controls the amount of

1. conditioned air flowing into the cabin.
2. ram air entering the cabin.
3. ram air leaving the aircraft.
4. conditioned air leaving the cabin.

710

CORRECT RESPONSES TO FRAME 2: 1. F 2. F 3. F 4. T

Frame 3

Illustrated is a cabin pressure regulator. This regulator is a fixed (can not be adjusted) isobaric single differential (5.0 psid) type. The text that you studied before this text gave information on this type of regulator.

This regulator has an unpressurized range, an isobaric range, and a differential range of pressurization. This type of air pressure regulator is used on some fighter aircraft.

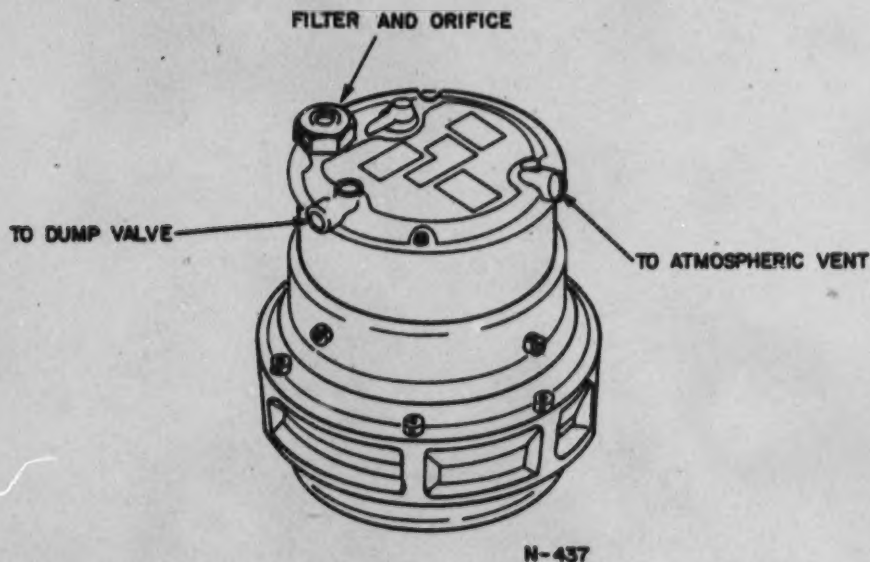


Diagram 2.

Answer the statements as true (T) or false (F).

1. The fighter aircraft pressure regulator has a normal and combat differential setting.
2. The three ranges of pressurization are unpressurized, isobaric, and differential.
3. The fighter aircraft has a fixed isobaric, single differential type of pressure regulator.

2544

CORRECT RESPONSES TO FRAME 3: 1. F 2. T 3. T

Frame 4

The illustration shows the inside of the regulator. You must keep in mind the isobaric section is used to control the first two ranges of pressurization. Also, the differential section is used to control the third range. The third range will keep a difference of 5.0 psid between cabin pressure and atmospheric pressure. The three ranges are: sea level to 8,000 feet (unpressurized), 8,000 feet to 24,000 feet (isobaric), and 24,000 feet on up (differential).

This type of cabin air pressure regulator has the outflow valve attached to it as shown in the illustration. The amount of air that will leave the pressurized area is controlled by opening and closing the outflow valve.

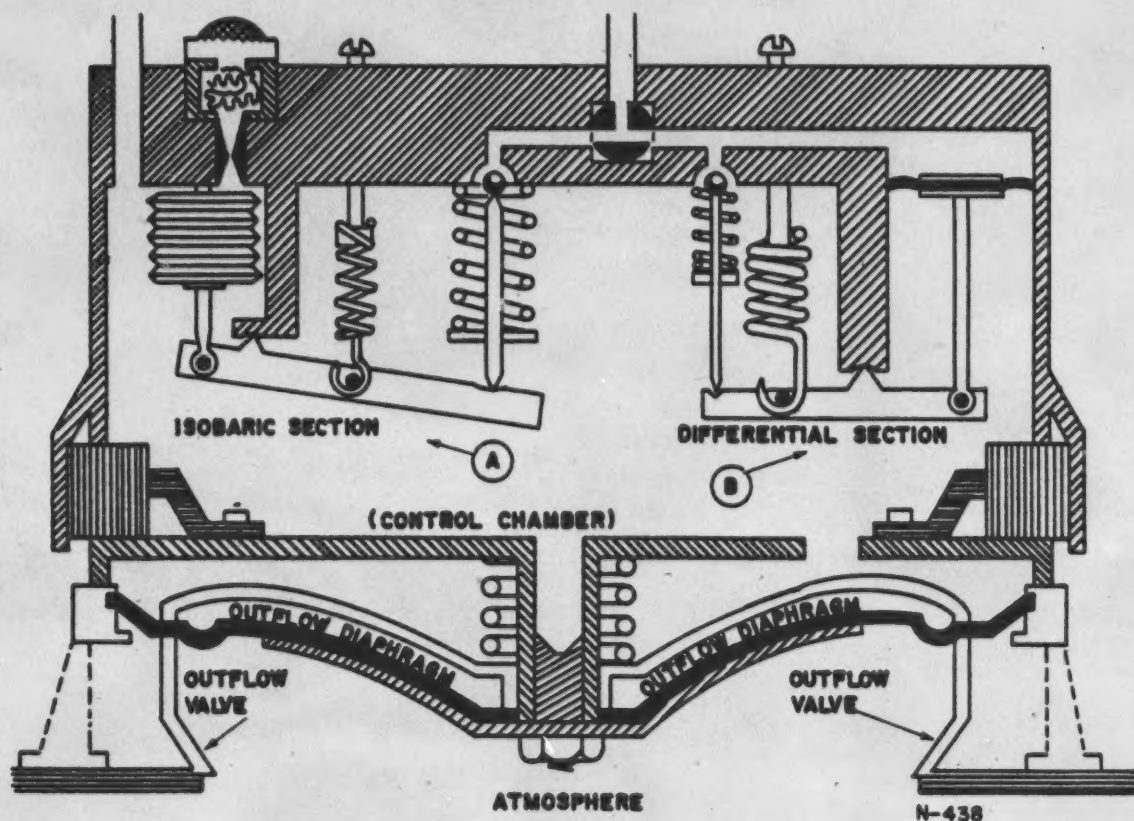


Diagram 3.

Match the letters in the illustration with the functions listed below.

1. Keeps cabin unpressurized between sea level and 8,000 feet.
2. Keeps a 3.0 psid between the cabin and atmospheric pressures.
3. Keeps an 8,000 feet cabin altitude pressure between aircraft altitudes of 8,000 feet and 24,000 feet.

Answer the statements true (T) or false (F).

4. The outflow valve is attached to the pressure regulator.
5. The outflow valve regulates the amount of air entering the pressurized area.
6. The outflow valve remains closed during the isobaric range.

2546

CORRECT RESPONSES TO FRAME 4: 1. A 2. B 3. A 4. T
5. F 6. F

Frame 5

Look at the diagram as we go through the operation of the regulator. This frame will give operation of one range of the isobaric section. Operation of the unpressurized range will be given in this frame.

The aneroid, shown in the diagram, is a sealed unit that has a set (fixed) pressure. Cabin pressure goes in the control chamber through the filter and orifice assembly. At this point pressure starts to build up. NOTE: From now on the pressure in the control chamber will be called "reference pressure." As REFERENCE PRESSURE builds up, the aneroid starts to collapse. The aneroid collapses because reference pressure on the outside of the aneroid is more than the pressure on the inside. As the aneroid collapses it opens the needle valve. With the needle valve open, air can flow to the atmosphere and cause a drop in reference pressure. The drop in pressure is caused by the rate of air flow through the orifice and open needle valve. The needle valve opening is larger than the orifice opening. Cabin pressure will now force the outflow valve open. With the outflow valve open, cabin air will vent to the atmosphere. The aircraft is now in the UNPRESSURIZED RANGE (sea level to 8,000 feet).

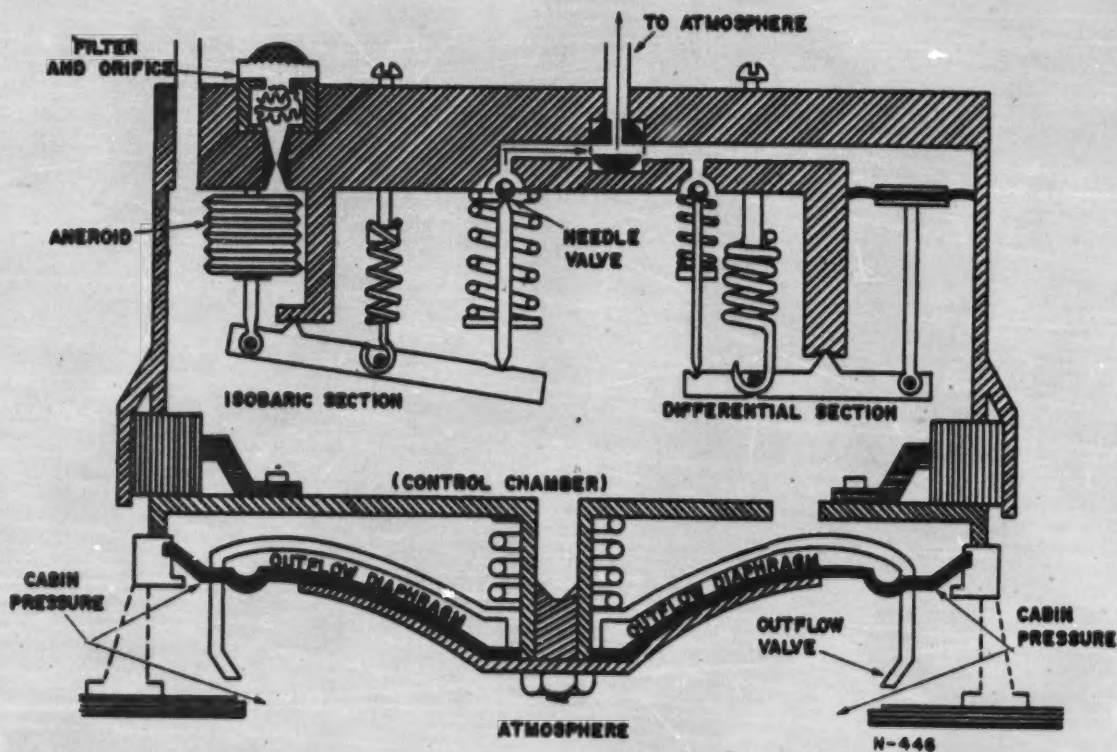


Diagram 4. 714

Answer the statements as true (T) or false (F).

1. The aneroid has a set (fixed) pressure.
2. The aneroid will collapse when reference pressure is greater than aneroid pressure.
3. Reference pressure cannot vent to the atmosphere as fast as it enters the control chamber.
4. Cabin pressure will open the outflow valve when reference pressure is vented to the atmosphere.
5. With the outflow valve always open, the aircraft is in the unpressurized range.

2548

CORRECT RESPONSES TO FRAME 5: 1. T 2. T 3. F 4. T
5. T

Frame 6

In Frame 5, the aircraft was in the unpressurized range. As the aircraft gains in altitude, the isobaric range will start to operate.

As the aircraft reaches and goes through an altitude of 8,000 feet, the pressure in the control chamber starts to drop. This drop in pressure is caused by the needle valve, for it is off seat (see Frame 5). As reference pressure drops, the aneroid will start to expand and cause the needle valve to close. With the needle valve closed, reference pressure starts to build up. Reference pressure will press down on the outflow valve diaphragm. This pressure, with the aid of the spring, will close the outflow valve (see Frame 5). With the outflow valve closed, cabin air will not continue to vent overboard to the atmosphere. Now pressure will build up in the cabin area. The isobaric section is set to keep the cabin at a pressure that does not change. The pressure is set to be the same as the atmospheric pressure at 8,000 feet of altitude. This reference pressure will be the same up to 24,000 feet of altitude. If reference pressure gets too high, the aneroid starts to collapse. As the aneroid collapses, it will cause the needle valve to open. Air in the control chamber can then vent to the atmosphere; reference pressure will drop. The cabin is kept at the desired pressure by the outflow valve, as it opens and closes. The pressurization system is now operating in the ISOBARIC RANGE (8,000 feet to 24,000 feet).

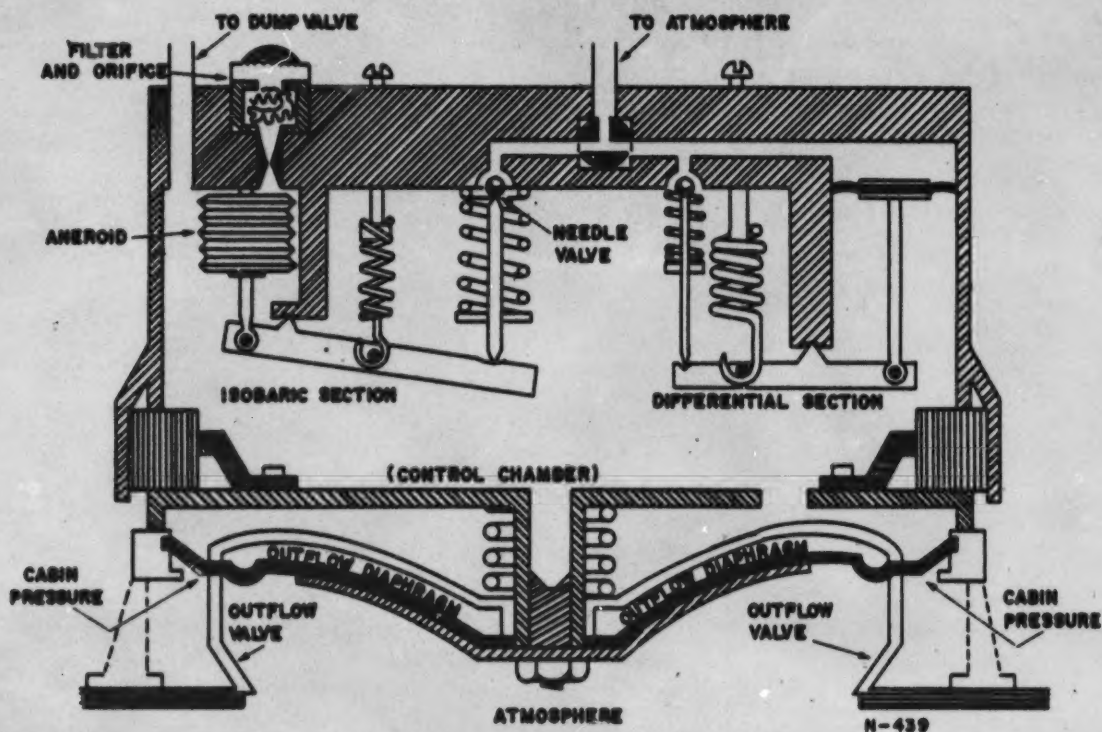


Diagram 5.

Answer the statements as true (T) or false (F).

1. At altitudes over 8,000 feet the aneroid will begin to close the needle valve.
2. With the isobaric needle valve closed, reference pressure will vent to the atmosphere.
3. As reference pressure builds up it will force the outflow valve closed.
4. When the outflow valve begins to close, cabin pressure will begin to build up.
5. If a certain constant isobaric pressure is exceeded, the aneroid will begin to collapse and again vent reference pressure to the atmosphere.

2550

CORRECT RESPONSES TO FRAME 6: 1. T 2. F 3. T 4. T
5. T

Frame 7

We have gone through operation of the unpressurized range and the isobaric range. Let us now see how the differential range works.

Look at the diagram; you will note that on one side of the differential diaphragm is atmospheric pressure. On the other side of the diaphragm is reference pressure. The differential spring is set so that it can keep a 5.0 psi difference in pressure between the cabin and atmosphere.

As the aircraft gains in altitude, atmospheric pressure continues to drop. At 24,000 feet atmospheric pressure is 5.70 psia. This pressure plus the 5.0 psi of differential spring tension, makes a total of 10.70 psia. The pressure of 10.70 psia is the pressure that will hold the differential pressure needle valve ON SEAT. When in the isobaric range, reference pressure was kept at 10.91 psia. This setting was held by operation of the aneroid. At this time, 10.91 psia is more than 10.70 psia, so the differential diaphragm is forced up. The diaphragm pulls the differential needle valve OFF SEAT. As air in the control chamber vents to the atmosphere, through the differential needle valve, the aneroid will collapse. As the aneroid collapses, it will push the isobaric needle valve ON SEAT. This cuts the isobaric section out of the system. Now that reference pressure has dropped, cabin pressure will build and push the outflow valve OFF SEAT. Air in the cabin can now vent to the atmosphere. As the cabin and reference pressures drop, the differential spring pulls the differential needle valve back ON SEAT. This will start the whole process again. This is how the regulator works in the DIFFERENTIAL RANGE (24,000 feet on up).

718

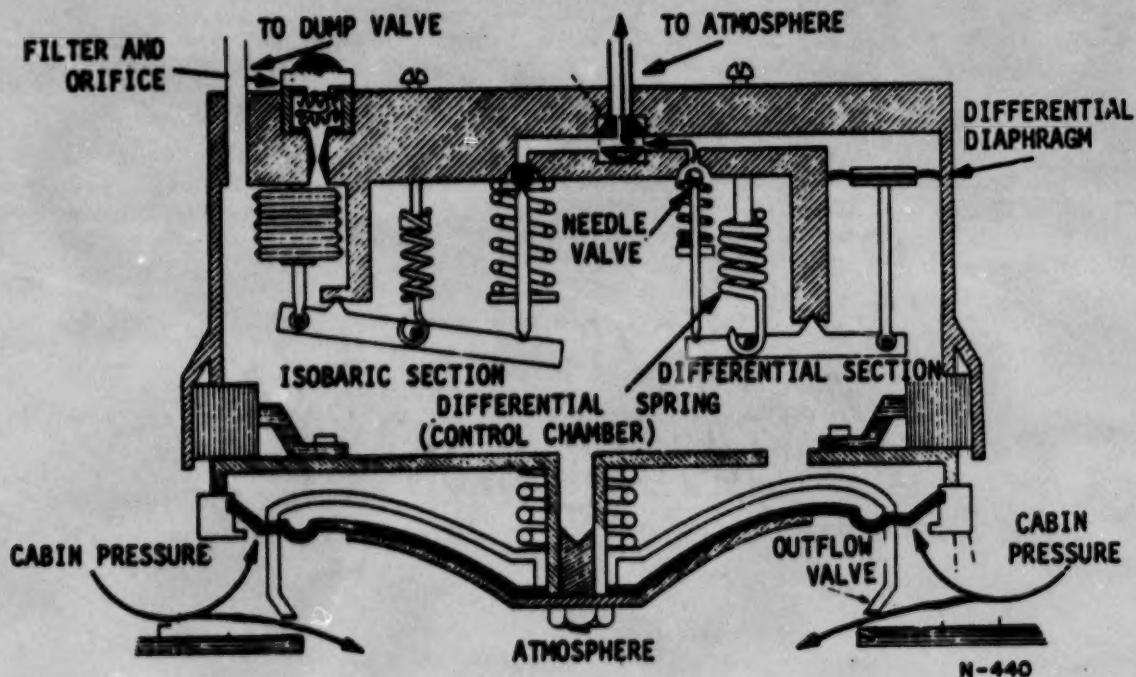


Diagram 6.

Answer the statements as true (T) or false (F).

1. The differential section of the pressure regulator stops operating above 24,000 feet.
2. Above 24,000 feet the isobaric needle valve will be fully closed.
3. The differential diaphragm has atmospheric pressure on one side and reference pressure on the other side.
4. If reference pressure reaches 5.2 psia greater than atmospheric pressure, the differential needle valve will open.
5. If reference pressure decreases, the outflow valve will open.

2552

CORRECT RESPONSES TO FRAME 7: 1. F 2. T 3. T 4. T
5. T

Frame 8

Using the diagram, identify the parts of the regulator.

1. Outflow valve.
2. Isobaric section.
3. Differential section.

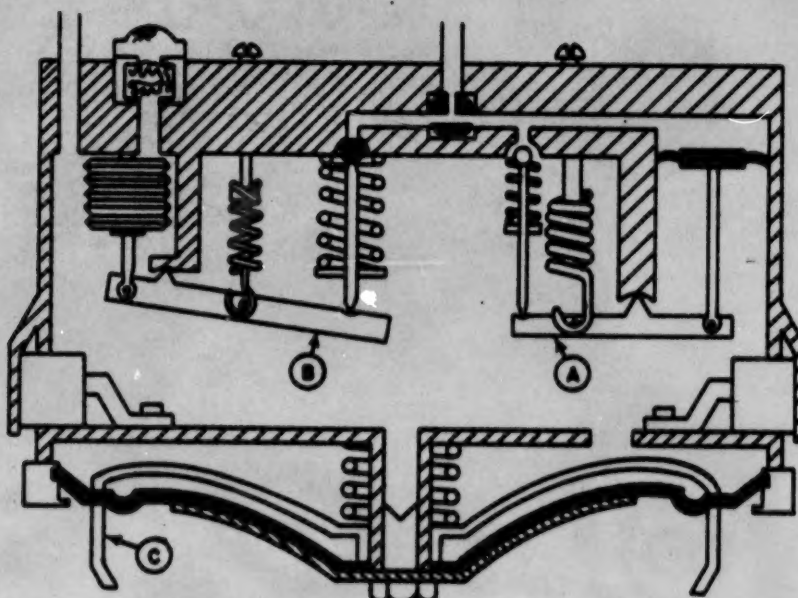


Diagram 7.

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CORRECT RESPONSES TO FRAME 8: 1. C 2. B 3. A

Frame 9

REVIEW QUIZ

Answer the statements as true (T) or false (F).

1. A pressurization system provides crew comfort by keeping a predetermined differential pressure in the cabin.
2. A pressurization system controls the amount of air leaving the aircraft cabin.
3. The cabin pressure regulator used on a fighter aircraft is a fixed isobaric, dual differential regulator.
4. The cabin pressure regulator provides three ranges of pressurization.
 5. The unpressurized range is from sea level to 8,000 feet.
 6. The differential range is from 8,000 feet to 24,000 feet.
 7. The outflow valve is attached to the cabin pressure regulator.
 8. The isobaric range is from 8,000 feet to 24,000 feet.
9. Cabin pressure will open the outflow valve when reference pressure is vented to the atmosphere.
10. An aneroid controls the isobaric section of the pressure regulator.
11. The differential diaphragm controls the differential section of the pressure regulator.
12. The differential range keeps a 6 psid between cabin pressure and atmospheric pressure.

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CORRECT RESPONSES TO FRAME 9: 1. T 2. T 3. F 4. T
 5. T 6. F 7. T 8. T
 9. T 10. T 11. T 12. F

Frame 10

Now you know how the cabin air pressure regulator works. Let us see what would take place if it did not work. What would keep cabin pressure from becoming so high that the windshield might be popped out, or the canopy might be blown off? You are right — a safety valve is needed. On some aircraft this valve is called the cabin pressure safety valve.

The safety valve, as you can see in the diagram, looks a lot like an outflow valve. The safety valve is put on the aircraft in the same way as the outflow valve.

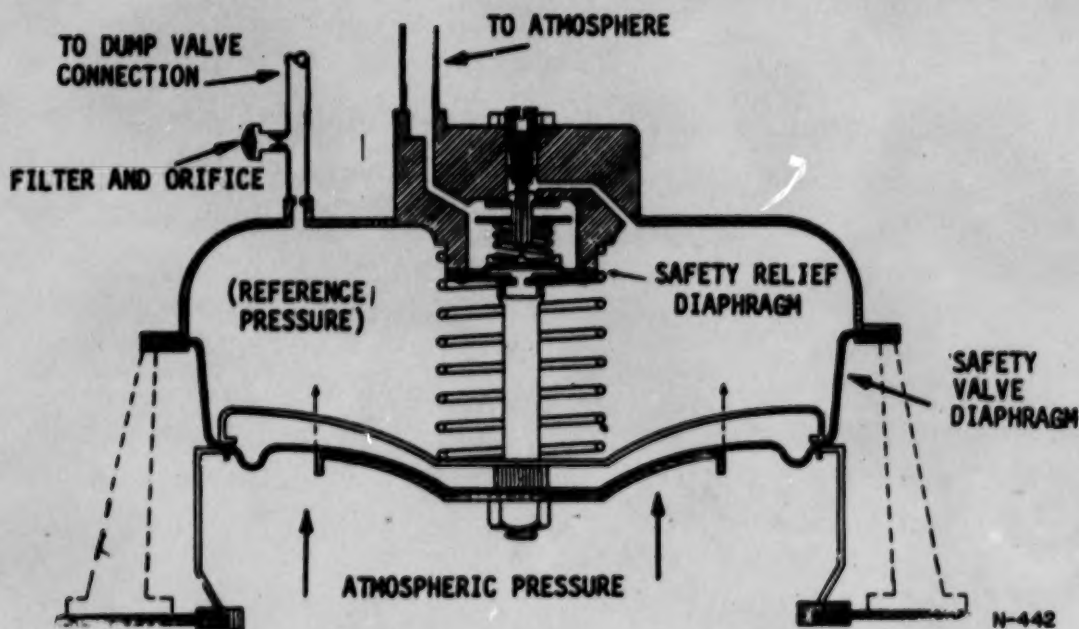


Diagram 8.

Answer the statements as true (T) or false (F).

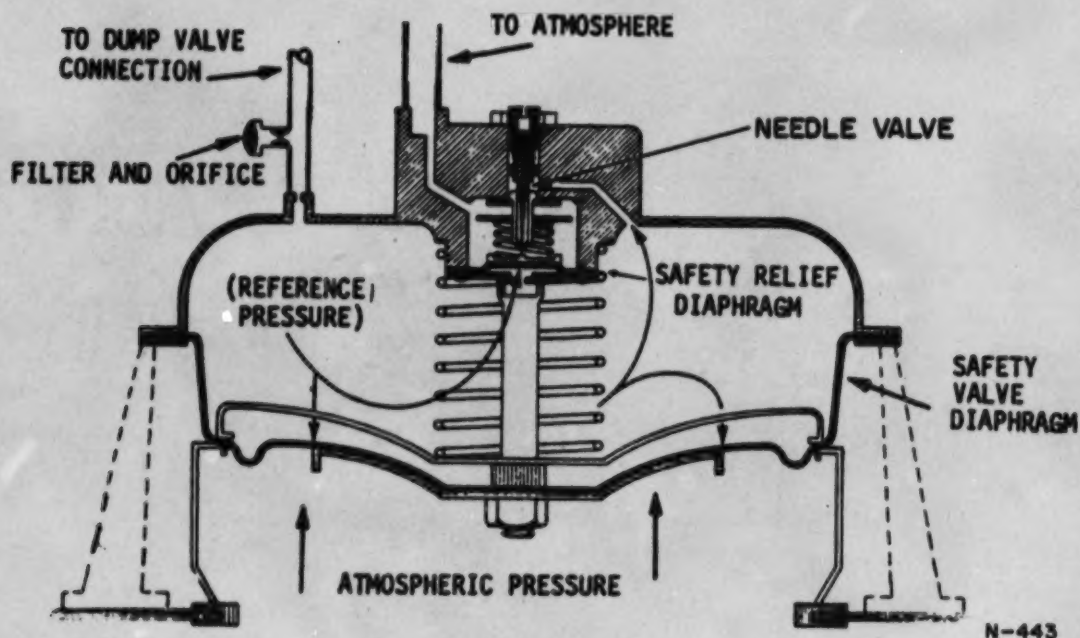
1. The safety valve relieves cabin pressure if the regulator should fail.
2. The safety valve is mounted on the aircraft in the same way that an outflow valve is mounted.
3. The safety valve is attached directly to the cabin pressure regulator.

CORRECT RESPONSES TO FRAME 10: 1. T 2. T 3. F

Frame 11

The cabin pressure safety valve can do these three functions:
 (1) The valve will dump cabin pressure at 5.25 psid, if the regulator failed to work. (2) It does not allow a negative cabin pressure (vacuum). Negative pressure is when atmospheric pressure is more than cabin pressure. (3) It helps to dump pressure when the cabin needs to be depressurized fast.

Cabin air flows into the safety valve through the filter and orifice assembly. Once cabin air is in the valve, the air is called REFERENCE PRESSURE. This reference pressure will build up and push down on the safety valve diaphragm and up on the safety relief diaphragm. Air tries to flow through the top passageway, on the right side, but is blocked by the needle valve that is now ON SEAT.



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Diagram 9.

Answer the statements as true (T) or false (F).

1. The cabin pressure safety valve performs three functions.
2. Cabin pressure and reference pressure will be at the same value.
3. The needle valve is held ON SEAT by spring tension.
4. Cabin air flowing into the safety valve is not restricted.

CORRECT RESPONSES TO FRAME 11: 1. T 2. T 3. T 4. F

Frame 12

Let us see what happens if the cabin pressure regulator fails. Keep in mind, atmospheric pressure will press down on the top side of the safety relief diaphragm. Reference pressure will push up on the back side of the diaphragm. When the differential section fails to ease cabin pressure at 5.0 psid, reference pressure in the safety valve builds up until it gets to 5.25 psid. At this time the safety relief diaphragm is pushed up. It in turn will push needle valve up and OFF SEAT. Now air can flow through the top passageway. Air flow is past the needle valve and out the atmospheric vent line. When reference pressure in the safety valve has eased, cabin pressure will push up on the safety diaphragm. Cabin pressure will OFF SEAT the outflow valve. This will allow the high cabin pressure to be eased through the outflow valve to the atmosphere. The safety valve will be fully open at 5.5 psid.

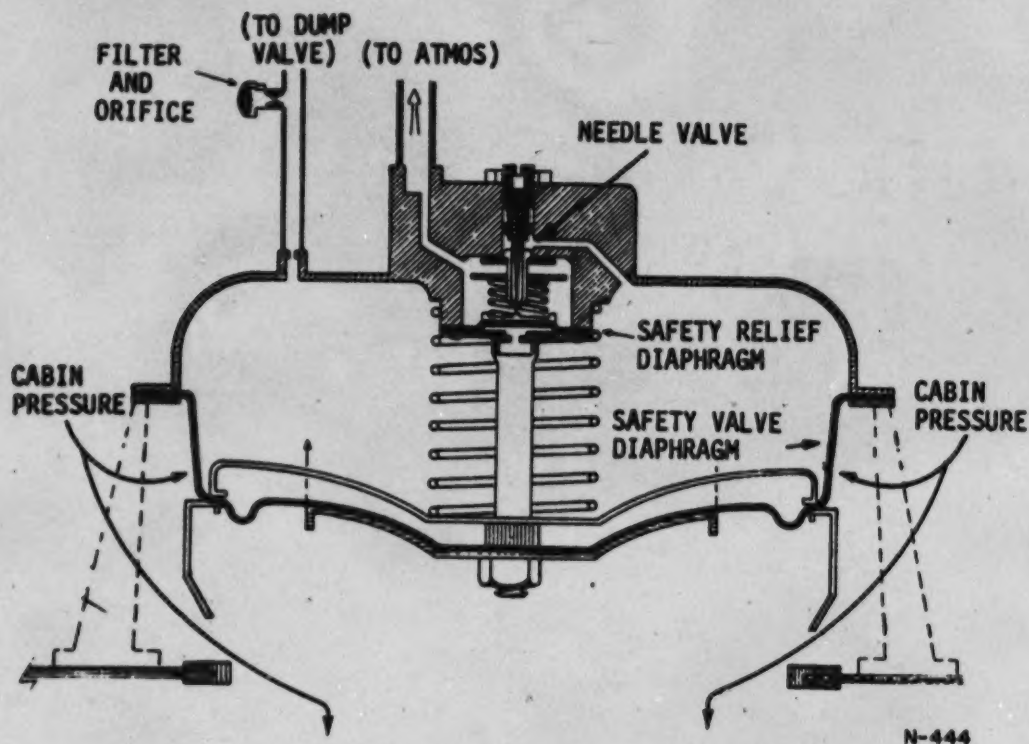


Diagram 10.

Answer the statements as true (T) or false (F).

1. The needle valve is pushed OFF SEAT when the safety relief diaphragm moves up.
2. Cabin pressure pushes the safety valve diaphragm up, lifting the outflow valve OFF SEAT.

CORRECT RESPONSES TO FRAME 12: 1. T 2. T

Frame 13

An aircraft is made to take only the stress force that moves out. If there was a case that would cause a stress force to move in, the aircraft could be crushed and the flight crew hurt. This could be the case when the pilot puts the aircraft in a fast dive. When in a dive atmospheric pressure on the outside of the aircraft is more than cabin pressure inside. This tends to cause a negative pressure (or vacuum) in the cabin. The stress force will then work inward. When this is the case the cabin pressure safety valve does the second job. Atmospheric pressure (which is now more than cabin pressure) will push the safety diaphragm up. This will lift the outflow valve OFF SEAT. Now air from the atmosphere can flow in and build cabin pressure up to the right value. With the inside and outside pressures now in balance, the aircraft will not be damaged.

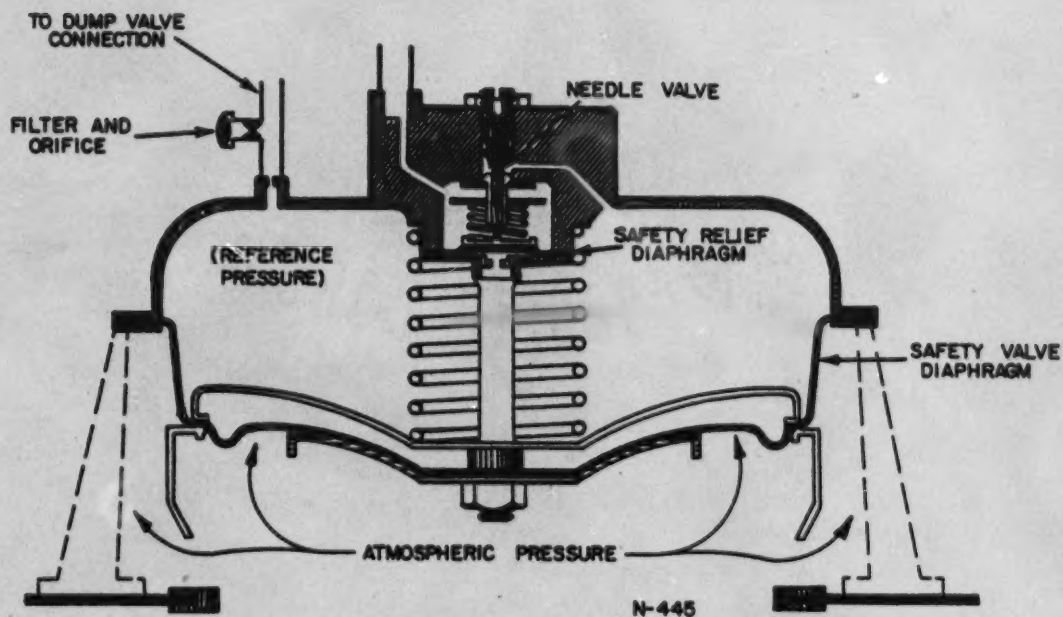


Diagram 11.

Answer the statements as true (T) or false (F).

1. The safety valve prevents a negative pressure in the cabin.
2. Under negative pressure conditions the needle valve is OFF SEAT.
3. When the outflow valve is pushed OFF SEAT the atmospheric and cabin pressures will equalize.
4. When the aircraft is in a rapid dive the atmospheric pressure will increase faster than cabin pressure.

2558

CORRECT RESPONSES TO FRAME 13: 1. T 2. F 3. T 4. T

Frame 14

Another function of the cabin pressure safety valve is to help dump cabin pressure when it needs to be dumped. You are now wondering, how does the valve help and when would the cabin need to be depressurized? First, the safety valve helps the cabin pressure regulator to dump cabin pressure. Second, if the cabin is filled with smoke or fuel fumes it will need to be depressurized. If this happens the cabin must be quickly vented to the atmosphere. A supply of ram air is used to force the smoke or fumes overboard.

The whole depressurization phase starts when the pilot pulls the emergency vent control knob. The knob is on the control panel. When the knob is pulled, it mechanically positions the dump valve. The dump valve is shown in the schematic.

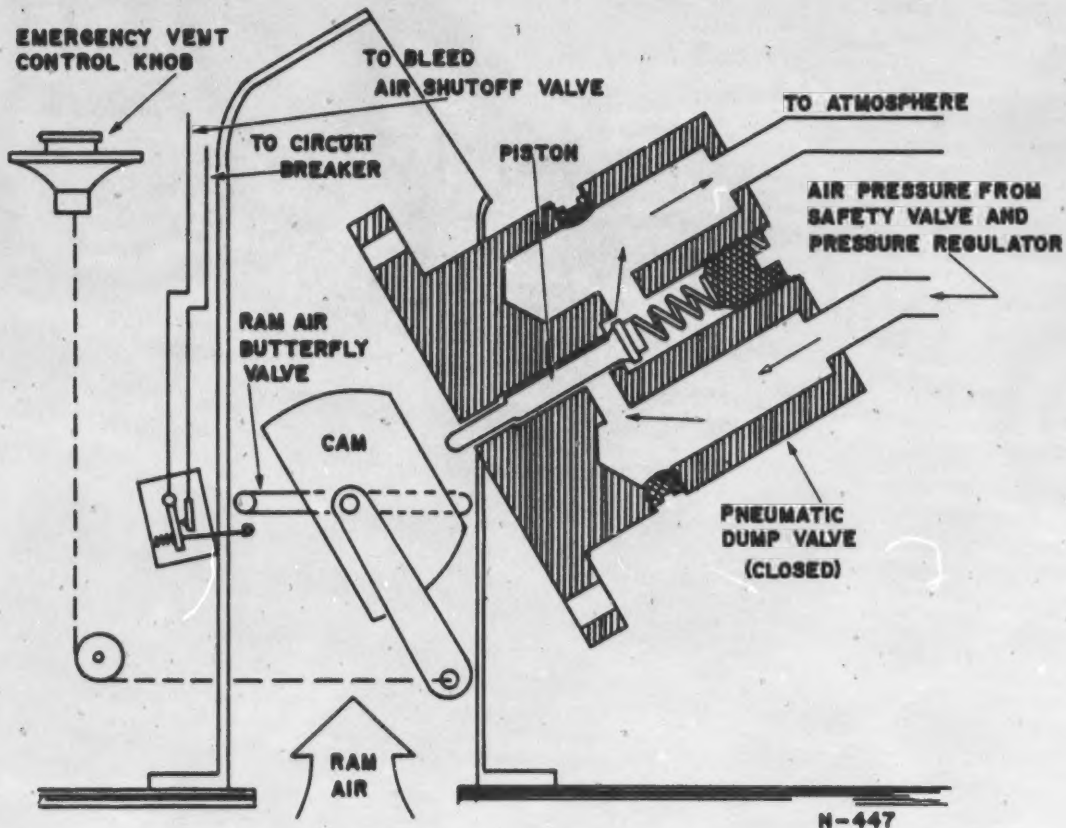


Diagram 12.

NO RESPONSE REQUIRED.

CORRECT RESPONSES TO FRAME 14: None Required.

Frame 15

Let us see what happens when the pilot pulls the emergency vent knob. (1) The cam and ram air butterfly valve turns in a clockwise direction. One end of the cam will push the valve up and OFF SEAT. **NOTE:** Just the butterfly is inside the ram air duct. The cam and lever are located on the outside of the duct. The cam and lever are on the same shaft. (2) Reference pressure from both the safety valve and the cabin pressure regulator is dumped overboard past the valve. (3) Cabin pressure can now push both outflow valves OFF SEAT. Cabin pressure is then dumped overboard. (4) The other end of the cam will touch and open the microswitch. This switch deenergizes the bleed air regulator and shutoff valve assembly (one valve), and this valve then closes. The flow of air that is used to drive the air conditioning system stops. This stops the flow of conditioned air to the cabin. (5) At the same time that the cam moved, the butterfly turned clockwise to the full open position. (6) Ram air can now flow into the cabin. Ram air flows out through the two outflow valves, carrying any smoke or fumes out with it.

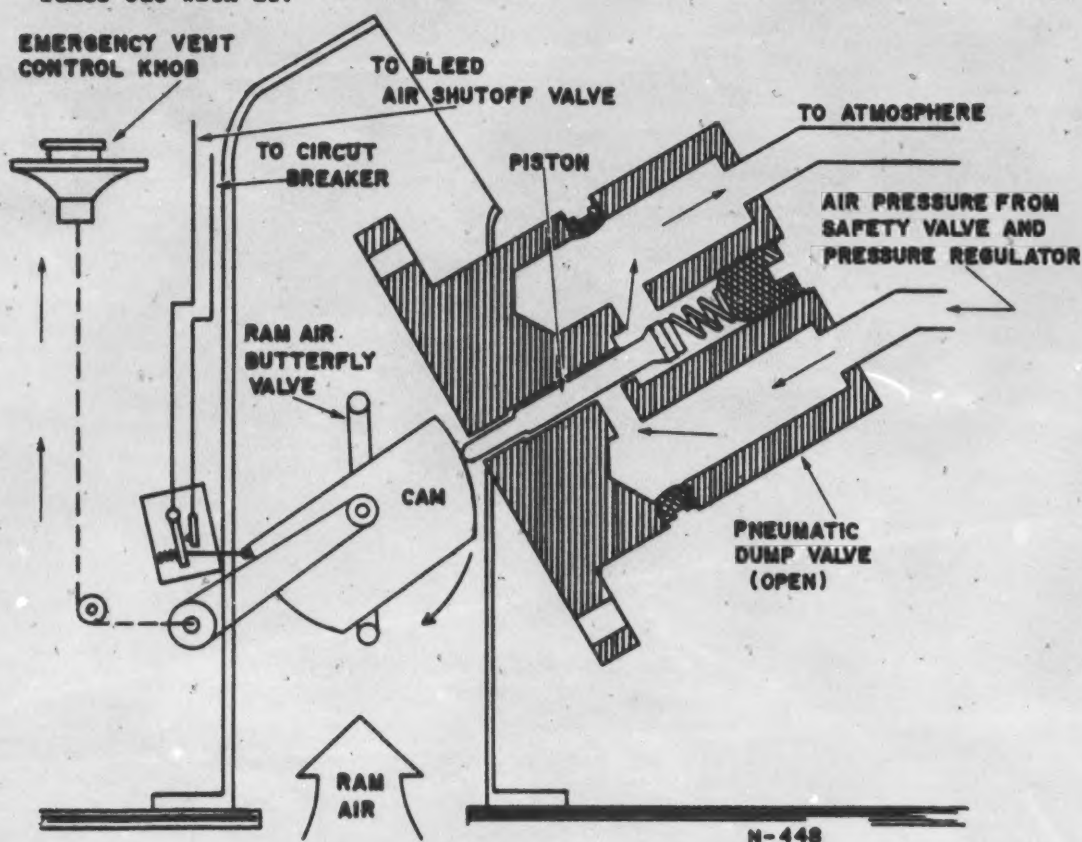


Diagram 13.

2560

Frame 15 (continued)

Below is a list of events that occur during emergency depressurization of the cabin. Number the events according to the order in which they take place.

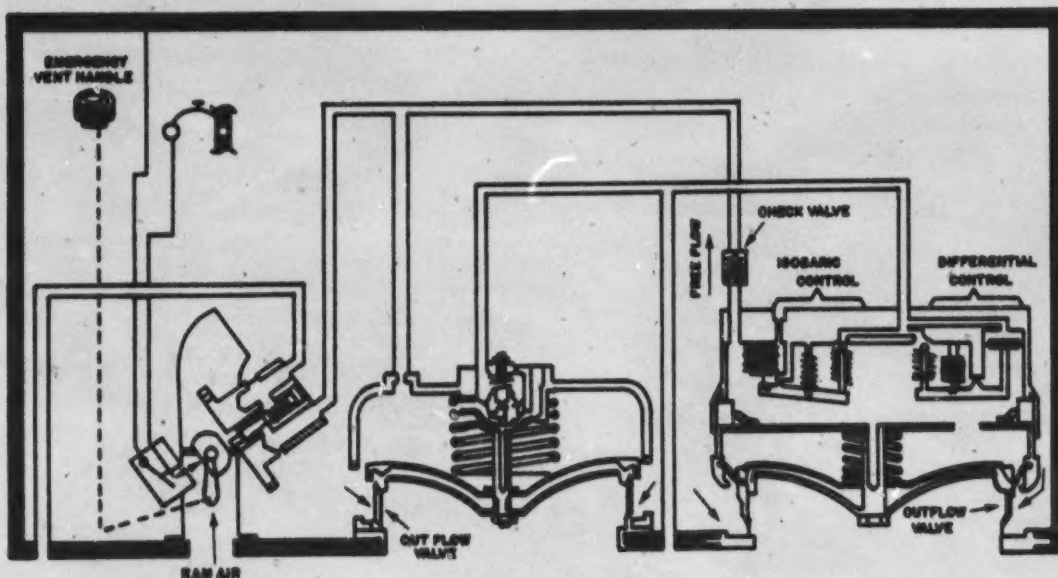
- A. Reference pressures are vented to the atmosphere, the air conditioning system stops, and ram air rushes into the cabin.
- B. The pilot pulls the emergency vent control knob.
- C. The outflow valves open and dump cabin pressure.
- D. The valve is pushed off seat and the microswitch is opened.
- E. Ram air flows through the cabin and out through the outflow valves carrying smoke and/or fumes out with it.
- F. The cam and butterfly valve rotate in a clockwise direction.

728

CORRECT RESPONSES TO FRAME 15: A. 4 B. 1 C. 5 D. 3
E. 6 F. 2

Frame 16

Just one item to go and you will be done. Look at the schematic and find the check valve. Note, it is in the line that connects the control chambers of the three valves. The line has to be there to allow reference pressure in the regulator to drop, when the dump valve is opened. What does the check valve do? Look at the regulator. Do you know what the orifice does? The orifice keeps the flow of cabin air from entering the control chamber faster than the needle valve can relieve it. Right? If there was no check valve, reference air (pressurized) from the safety valve could flow into the regulator and mix with the air that flows through the orifice. This volume of air would be more than the needle valve could handle. Result: The regulator outflow valve would be held ON SEAT all of the time. The regulator could not properly control cabin pressure.



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Diagram 14.

NO RESPONSE REQUIRED.

2562

Frame 17

Answer the following statements as true (T) or false (F).

1. The purpose of a pressurization system is to keep a pre-determined pressure in the aircraft cabin. This pressure provides crew comfort and safety.
2. The pressurization system controls the amount of conditioned air entering the cabin.
3. The pressurization system used on a fighter aircraft is a fixed isobaric, dual differential system.
4. One function of the isobaric section is to prevent the cabin from being pressurized between sea level and about 8,000 feet.
5. The three functions of the cabin air safety valve are (1) help dump cabin pressure, (2) relieve excessive cabin pressure if the regulator fails, (3) prevent a negative cabin pressure.
6. The emergency vent knob is pulled to start the safety valve.
7. The check valve installed in the pressurization system prevents regulator reference pressure from escaping to the safety valve.
8. The differential section of the regulator maintains a 5.0 psid between the cabin and atmosphere above 24,000.
9. The isobaric section of the regulator maintains an 8,000 ft. cabin altitude pressure at aircraft altitudes between 8,000 and 24,000 feet.
10. The negative pressure relief function of the safety valve operates when atmospheric pressure is less than reference pressure.
11. One outflow valve is attached directly to the pressure regulator.
12. Both outflow valves open during emergency cabin depressurization.
13. The cabin pressure safety valve is a two function valve.
14. The excessive pressure relief section of the safety valve will be fully open at 5.5 psid.
15. When the pneumatic dump valve is operated, reference pressure is vented from the safety valve to the atmosphere and the safety valve helps dump cabin pressure.

730

CORRECT RESPONSES TO FRAME 17:

1. T
2. F
3. F
4. T
5. T
6. F
7. F
8. T
9. T
10. F
11. T
12. T
13. F
14. T
15. T

2564

RESPONSE SHEET 3ABR42231-PT-315A

FIGHTER PRESSURIZATION SYSTEM

Frame 1

1. _____ 3. _____
2. _____

Frame 2

1. _____ 3. _____
2. _____ 4. _____

Frame 3

1. _____ 3. _____
2. _____

Frame 4

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

Frame 5

1. _____ 4. _____
2. _____ 5. _____
3. _____

Frame 6

1. _____ 4. _____
2. _____ 5. _____
3. _____

Frame 7

1. _____ 4. _____
2. _____ 5. _____
3. _____

Frame 8

1. _____ 3. _____
2. _____

Frame 9

1. _____ 7. _____
2. _____ 8. _____
3. _____ 9. _____
4. _____ 10. _____
5. _____ 11. _____
6. _____ 12. _____

Frame 10

1. _____ 3. _____
2. _____

Frame 11

1. _____ 3. _____
2. _____ 4. _____

Frame 12

1. _____
2. _____

Frame 13

1. _____ 3. _____
2. _____ 4. _____

Frame 14

No Response
Required

Frame 15

A. _____ D. _____
B. _____ E. _____
C. _____ F. _____

Frame 16

No Response
Required

Frame 17

1. _____ 9. _____
2. _____ 10. _____
3. _____ 11. _____
4. _____ 12. _____
5. _____ 13. _____
6. _____ 14. _____
7. _____ 15. _____
8. _____



Technical Training

Aircraft Environmental Systems Mechanic

BOMBER PRESSURIZATION SYSTEM

6 November 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343d Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42231 instructional system. The material contained herein has been validated using thirty 42010 students enrolled in the 3ABR42231 Course. 90% of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required (32) minutes to complete the text.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Explain the function of pressurization system components.
2. State pressurization system operation.

INSTRUCTIONS

This program is presented in small steps called "frames." After each frame you are asked to identify the correct statements. You are also asked to match some statements. Use the response sheet to record your answers. DO NOT MARK IN THIS TEXT. The correct answers can be found at the top of the page after each frame. If your answer is correct, proceed to the next frame. If your answer is wrong, go back and reread the material before going to the next frame.

Supersedes 3ABR42231-PT-315B, 24 May 1973, which may be used until existing stocks are exhausted.

OPR: TAS

DISTRIBUTION: X

TAS - 100; TTVGC - 2

The schematic is of a B-52 pressurization system. Starting at the upper left of the schematic, the parts are:

Pressure release switch.

Master pressurization switch.

Pressure regulator.

Dump control valve.

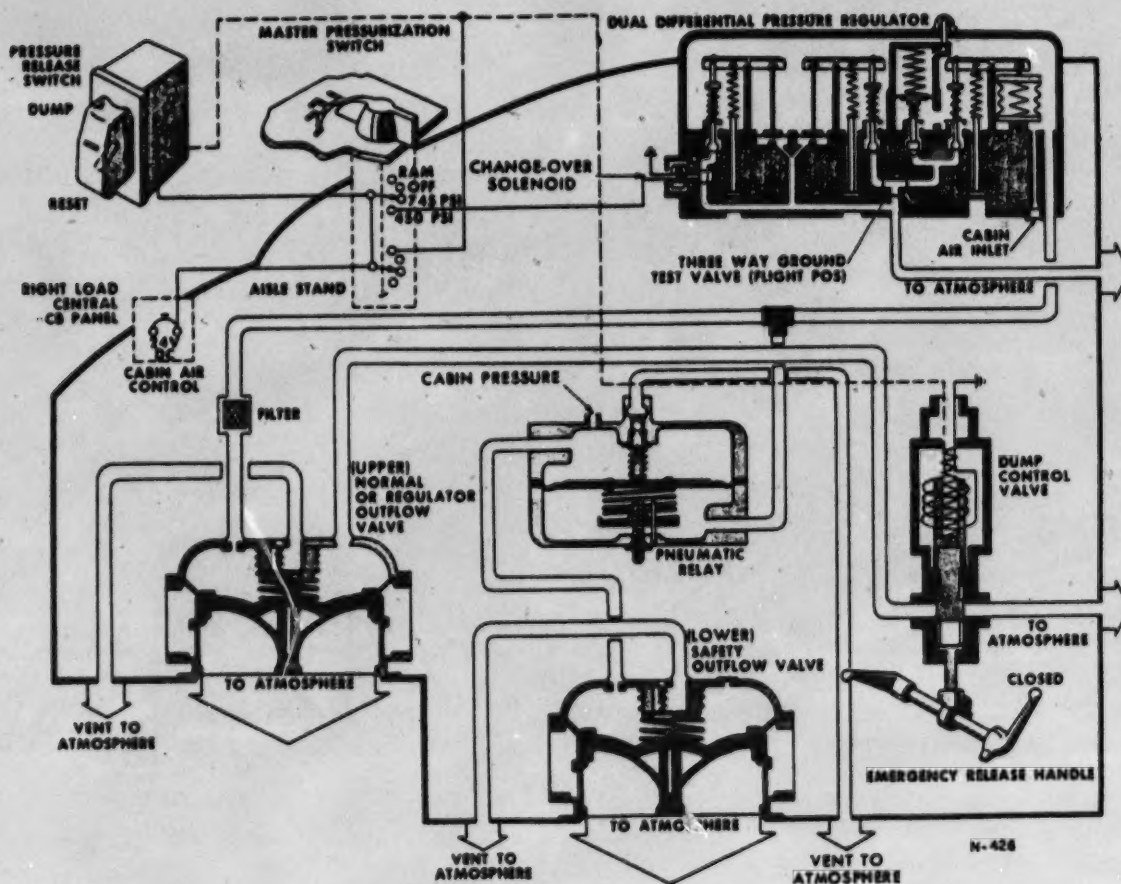
Emergency release handle.

Pneumatic relay.

Safety outflow valve.

Normal outflow valve.

Study the schematic to become familiar with the parts before continuing.



NO RESPONSE REQUIRED

2568

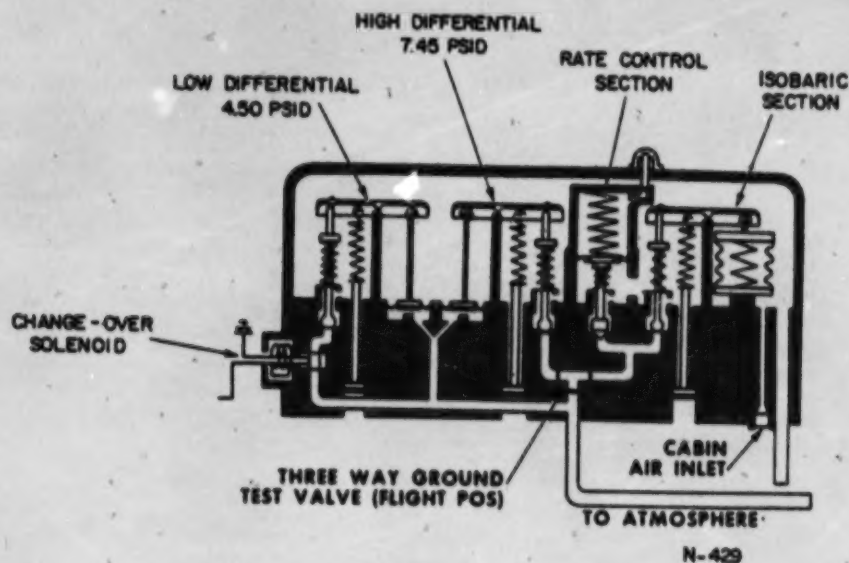
Frame 2

The first part we will discuss is the pressure regulator. It is made up of an isobaric section, two differential sections, a change-over solenoid, a three-way ground test valve, and a rate control section.

The isobaric section works just like the ones you have learned. We will not discuss this one in detail.

The low differential is for use when the plane is in a combat zone. The lower the differential pressure the slower the decompression rate if any enemy bullet rips through the cabin area.

The high differential is used when the plane is out of a combat zone. Note the pressure settings for each of the differential sections.



Dual Differential Pressure Regulator.

Answer the statements as true (T) or false (F).

1. The low differential will be used in a combat zone.
2. The isobaric section works just like the one in the F-4C cabin pressure regulator.
3. The high differential will be used when the plane is in a combat zone.
4. The change-over solenoid is part of the low differential section.

Correct Responses to Frame 2: 1. T 2. T 3. F 4. T

Frame 3

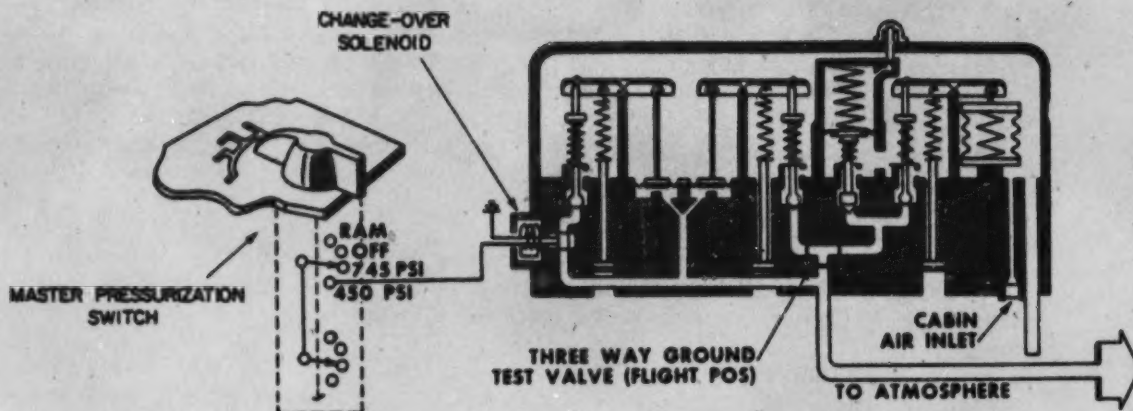
The change-over solenoid is in the open position, when the pilot sets the master pressurization switch to the 4.50 (low differential) psid position. The plunger moves to the right, opening the differential to atmosphere. In all other switch positions the solenoid is deenergized, and will close the atmospheric vent line. This will keep the low differential from relieving pressure. The low differential will open the needle valve at 4.50 psid, but nothing will happen since the deenergized solenoid has the vent line closed and head pressure can not be dumped.

The sole job of the three-way ground test valve is to ground test the cabin pressurization system. Look at the schematic as we discuss the valve. The valve has three positions which are:

1. **FLIGHT POSITION** - In this position the isobaric, rate control, and high differential sections are all connected to the atmospheric vent line. The regulator can now operate. The three-way valve is safety wired to the flight position.

2. **TEST ONLY-DIFFERENTIAL ON POSITION** - Think of the valve as if it had been moved 1/4 turn clockwise. This shuts off the rate control and isobaric sections. When pressure is pumped to the regulator, the rate control and isobaric sections do not work for the vent to the atmosphere is blocked. Head pressure will continue to build up. If the change-over solenoid is energized, head pressure will be relieved at 4.50 psid through the low differential. If the solenoid is deenergized, head pressure will climb to 7.45 psid since the low differential will not now work. Keep in mind 7.45 psid is the high differential setting. With the three-way valve to the **TEST ONLY-DIFFERENTIAL ON** position we can ground test both differential sections for proper operation.

3. **TEST ONLY-ALL OFF POSITION** - Think of the three-way valve as if it had been moved 1/2 turn clockwise from the position shown. With the change-over solenoid deenergized, all vent lines are blocked and the regulator can not control cabin pressure. This tests operation of the outflow valves (see frame 1) as safety valves. We will have more on the outflow valves later.



N-430

Answer the statements as true (T) or false (F).

1. The change-over solenoid is energized closed.
2. The three-way ground test valve is used to ground test the cabin pressurization system.
3. When the three-way valve is in the flight position, the isobaric section can not work.
4. When the three-way valve is in the test only, differential on position, head pressure will be relieved by one of the differential sections.
5. If the change-over solenoid is closed, the low differential will still work but its operation will be ineffective.
6. The setting of the high differential section is 7.45 psid.
7. If the three-way valve is in the test only, all off position and the change-over solenoid is deenergized, the regulator will not work.
8. The three-way valve is normally safetywired to the test only, differential on position.
9. The setting of the low differential section is 4.50 psid.
10. When the low differential needle valve is off seat, head pressure is vented to the atmosphere through the three-way valve.

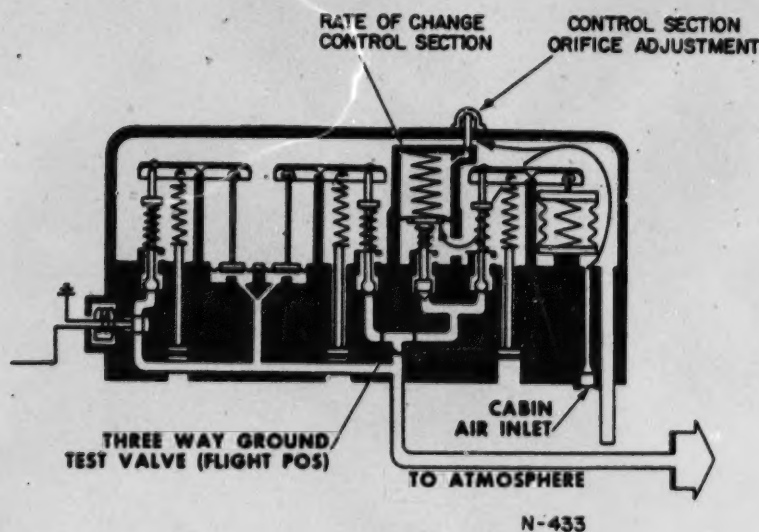
Correct Responses to Frame 3: 1. F 2. T 3. F 4. T
 5. T 6. T 7. T 8. F
 9. T 10. F

Frame 4

The rate control section protects the flight crew from too fast a rise in pressure. The section keeps the buildup of cabin pressure to 1 psid per minute. Here is when and how it works.

Suppose the master pressurization switch is in the 4.50 psid position. The pilot decides to change the switch to the 7.45 psid position. The change-over solenoid will close. The low differential, that has been controlling cabin pressure, stops. Cabin and head pressures tend to jump to 7.45 psid, the high differential setting. It does not sound like much, but a fast rise in pressure of 3 psid could burst ear drums or damage the plane. Look at the schematic to see how this is prevented by the rate control section.

Notice that as head pressure increases air is free to flow to the bottom of the rate control section. On top, head pressure is restricted by the adjustable orifice. Since head pressure can build up much faster on the bottom than on the top, the rate control section diaphragm moves up. The needle valve is pulled off seat to vent part of the head pressure to the atmosphere. When head pressure on top of the control diaphragm does catch up, it, plus spring tension, moves the needle valve back on seat. This process continues until the high differential setting is reached. During the process, cabin pressure is held to a 1 psid increase per minute.



2572

Frame 4 (Cont'd)

Answer the statements as true (T) or false (F).

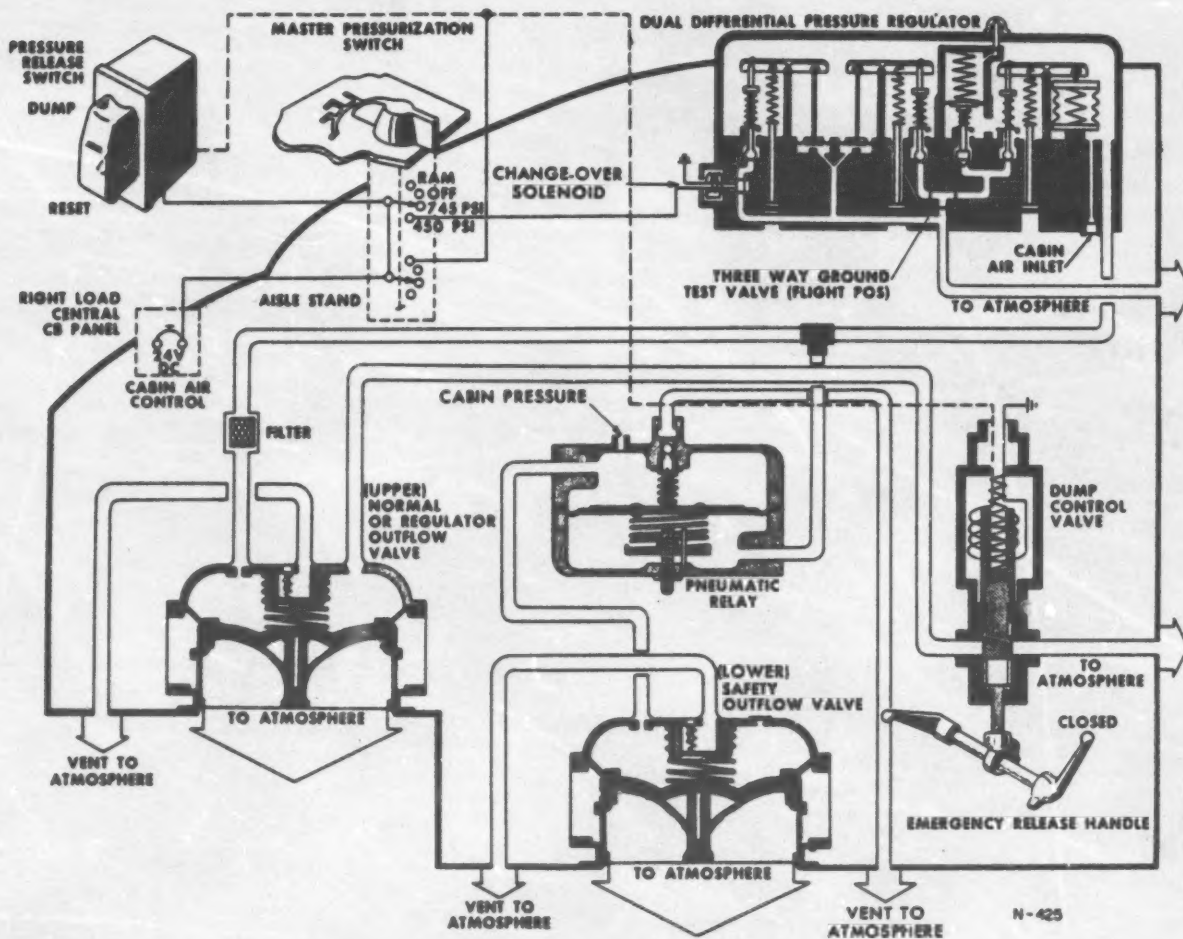
1. The rate of change control section holds cabin pressure buildup to 1 psid per minute.
2. A too fast an increase in cabin pressure could injure the flight crew.
3. Head pressure builds up faster in the top of the control section than it does in the bottom.
4. If cabin pressure increases faster than 1 psid per minute, it may be because the adjustable orifice is opened too far.
5. Cabin pressure tends to climb fast when the pilot changes the master pressurization switch from 4.50 psid to 7.45 psid.

740

Correct Responses to Frame 4: 1. T 2. T 3. F 4. T 5. T 2593

Frame 5

The crew compartment is too large for one outflow valve to take care of the great volume of air to be relieved. Therefore, the B-52 aircraft has two outflow valves. The difference between the two is that the normal or regulator outflow valve has three lines connecting to it. The safety outflow valve just has two. Both valves open to relieve high cabin pressure. They also relieve negative pressure at 0.36 psid.

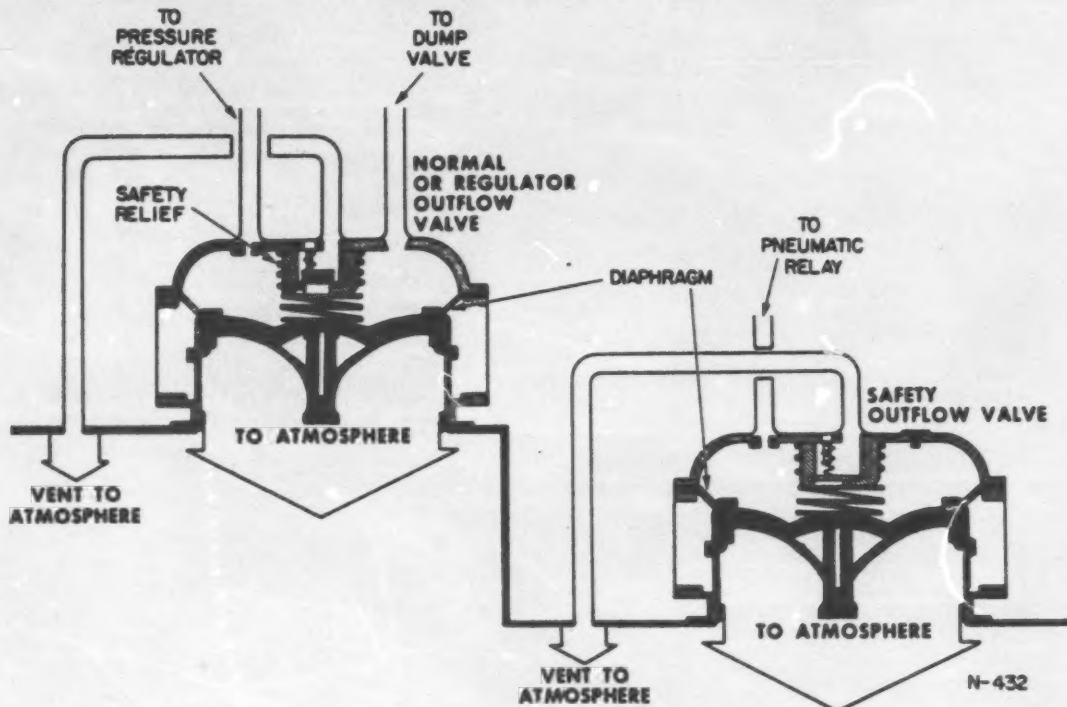


NO RESPONSE REQUIRED

2574

Frame 6

In each of the outflow valves there is a safety relief section. Here is how it works. Suppose the pressure regulator failed to hold cabin pressure to 7.45 psid (high differential setting). When cabin and head pressures reach 8.1 psid the safety relief valves are pushed up and off seat. Head pressure can then vent to the atmosphere. Cabin pressure, which is now more than head pressure, will push the diaphragms up, open the outflow valves, and vent to the atmosphere.



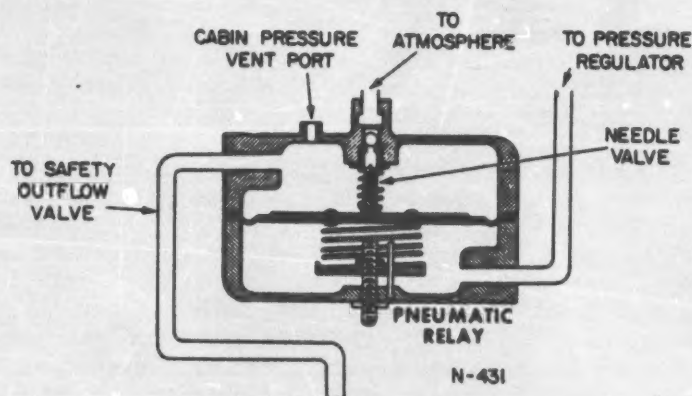
Answer the statements as true (T) or false (F).

1. Each outflow valve contains a safety relief section.
2. Both outflow valves operate to relieve negative and cabin pressures.
3. Two outflow valves are used because of the size of the crew compartment.
4. Cabin pressure pushes the outflow valves off seat when the head pressure has been vented to the atmosphere.
5. The two outflow valves are identical in construction and operation.

Correct Responses to Frame 6: 1. T 2. T 3. T 4. T ²⁵⁷⁵
5. T

Frame 7

Look at the schematic in frame 5 and find the pneumatic relay. As you can see, this part is between the safety valve and pressure regulator. In the relay (see diagram) there is a diaphragm separating the top and bottom halves. On top of the diaphragm is a needle valve. It is held closed by the spring that pushes up on the bottom of the diaphragm. Cabin pressure is on both sides of the diaphragm. Pressure goes in the bottom half through the line that is connected to the regulator. Pressure goes in the top half through the cabin pressure vent port. Keep in mind the relay is placed inside the pressurized crew compartment.



Answer the statements as true (T) or false (F).

1. The relay is placed between the safety outflow valve and the pressure regulator.
2. The needle valve is held off seat by spring tension.
3. Cabin pressure acts on both sides of the diaphragm.
4. The relay is placed inside the cabin. Therefore, cabin pressure goes in the top of the relay through the cabin pressure vent port.
5. Cabin pressure in the bottom of the relay has to pass through the pressure regulator.

2576

Correct Responses to Frame 7: 1. T 2. F 3. T 4. T
5. T

Frame 8

The job of the pneumatic relay is to make sure that the safety outflow valve operates fast. That does not tell you much but here is what it means.

You can not tell by looking at the schematic in frame 5, but the safety valve (in the lower crew compartment) and the pressure regulator are a long way from each other. The normal outflow valve is close to the regulator in the upper crew compartment. Keep in mind, the B-52 is a big aircraft. If there was no relay, the safety valve head pressure would have to vent through the regulator, just like the head pressure from the other outflow valve. By the time safety head pressure reached the regulator, the other outflow valve would have opened. Keep in mind, one outflow valve can not take care of the great volume of air to be relieved. The pneumatic relay makes sure that both outflow valves operate at the same time. The valve is the same distance from the regulator as the normal outflow valve. When the regulator kicks open (isobaric or differential operation) pressure is dumped from the bottom side of the pneumatic relay. The pressure in the top side of the relay can then push the diaphragm down. This will open the relay needle valve. Head pressure from the safety outflow valve can now vent past the relay needle valve to the atmosphere. The safety outflow valve opens and helps relieve cabin pressure. Safety reference pressure does not go back to the regulator to be vented, it vents through the relay valve. This lets the safety outflow valve operate quicker.

Answer the statements as true (T) or false (F).

1. The safety outflow valve is placed close to the regulator.
2. Safety outflow valve reference pressure will vent through the regulator.
3. Head pressure gets into the safety outflow valve from the top of the pneumatic relay.
4. The pneumatic relay is placed about half way between the two outflow valves.
5. The safety outflow valve is placed in the lower crew compartment while the normal outflow valve and the pressure regulator are placed in the upper crew compartment.

744

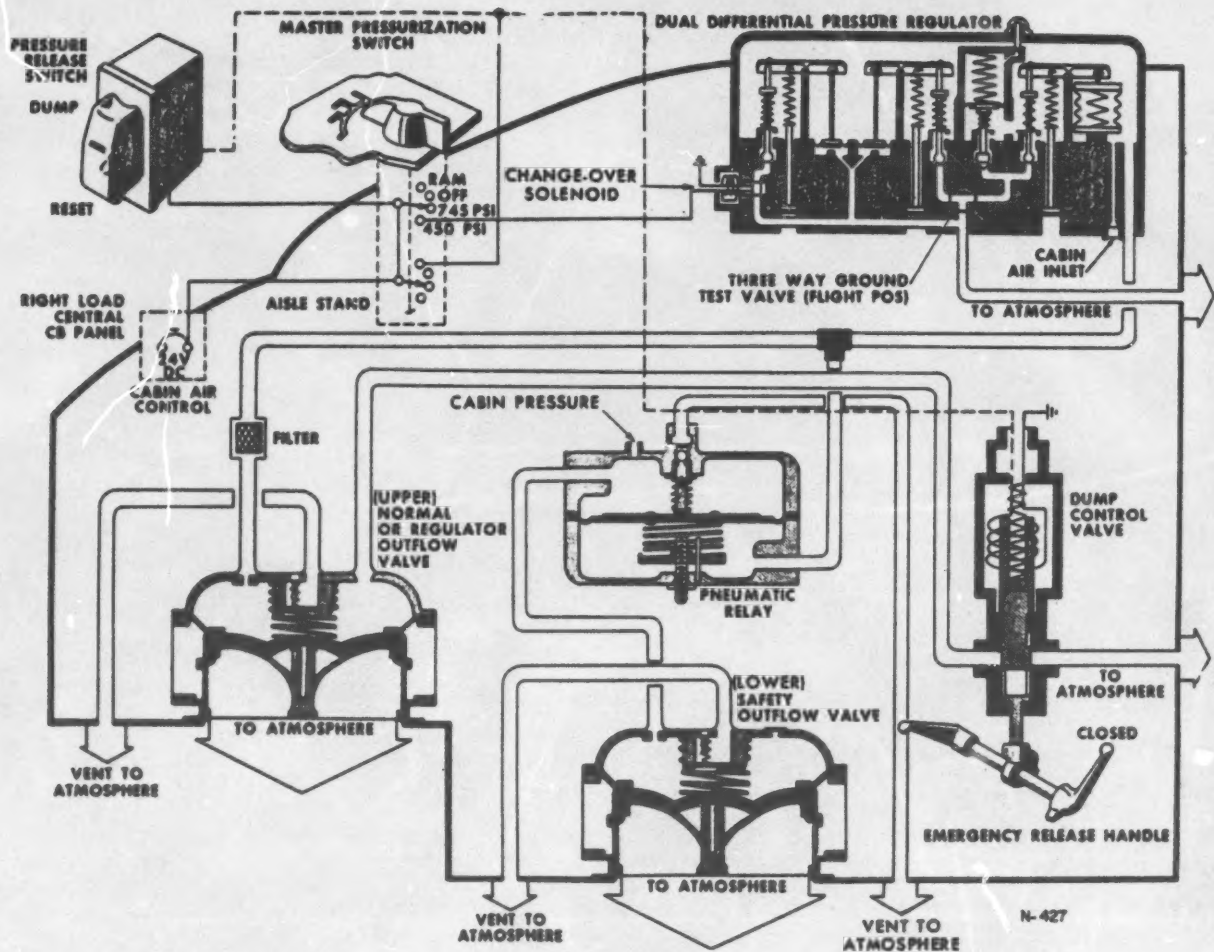
Correct Responses to Frame 8: 1. F 2. F 3. T 4. F
5. T

2577

Frame 9

The dump valve can be operated electrically or manually. The valve job is to help dump cabin pressure in an emergency situation.

When the pilot puts the pressure release switch to the dump position, the dump valve is energized and the solenoid lifts the spool off seat. This dumps head pressure from the normal outflow valve. At the same time, pressure is dumped from the bottom side of the pneumatic relay through the normal outflow valve. Then through the dump valve. This will cause the relay needle valve to open and dump safety outflow valve head pressure. Both outflow valves open and cabin pressure is dumped to the atmosphere. All of this takes place in just a few seconds. The emergency release handle is used by the pilot in case electrical power fails to open the dump valve.



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2578

Frame 9 (Cont'd)

Answer the statements as true (T) or false (F).

1. The dump valve can be operated manually.
2. The job of the dump valve is to help dump cabin pressure in an emergency situation.
3. The dump valve is normally operated electrically.
4. The pilot opens the dump valve by positioning the master pressurization switch.
5. The solenoid is deenergized to open the dump valve.
6. Head pressure from both outflow valves will vent through the dump valve.

746

2579

PROGRAMMED TEXT
3ABR42331-PT-315C

Technical Training

Aircraft Environmental System Mechanic

VARIABLE ISOBARIC PRESSURIZATION

8 December 1978



CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42331 Instructional System. The material contained herein has been validated using 32 42010 students enrolled in the 3ABR42331 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 36 minutes to complete the text.

OBJECTIVES

Match the components of cabin pressurization systems to their function and/or operation. 70% of the components must be matched correctly.

INSTRUCTIONS

This program is presented in small steps called frames. After each frame you are asked to make a response to exercises. Enter your responses on the response sheet. DO NOT MARK IN THIS TEXT. In some instances you are asked to identify or match items. The correct answers are found at the beginning of each new frame. If your answer is correct, proceed to the next frame. If your answer is wrong, reread the material before you proceed to the next frame.

Supersedes 3ABR42231-PT-316C, 6 November 1975, which may be used until existing stocks are exhausted.

OPR: 3370 TCHTG

DISTRIBUTION: X

3370TCHTG/TTGU-P - 400; TTVSA - 1

The C-141 aircraft (plane) has an example of a pressurization system with a variable isobaric section. The whole system is made up of just three major parts. Look at the schematic (figure 1) on the next page and find the automatic controller, manual controller and the outflow/safety valve.

You probably noticed that this system does not have a cabin pressure regulator. That is because the three major parts of the system work together to regulate and control cabin pressure. Get familiar with the schematic for a few minutes then we will discuss each part individually.

NO RESPONSE REQUIRED

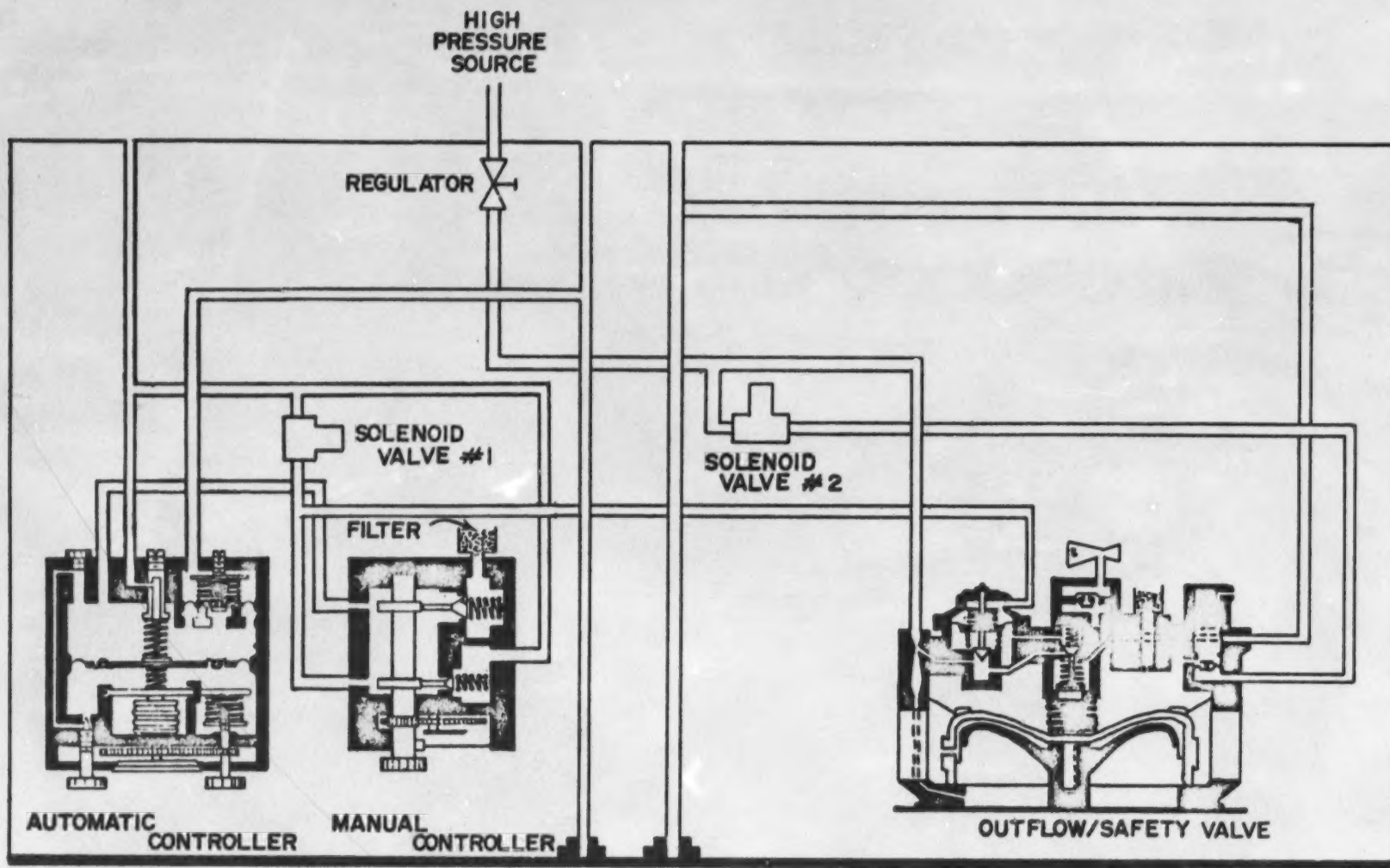


Figure 1. Cabin Pressure Control Schematic.

Correct Response to Frame 1: None Required.

Frame 2

The first part is the automatic controller. It is made up of an isobaric section that can be set in flight, a rate control adjuster, and a differential section. The front of the automatic controller is shown in figure 2. The knob in the left is the rate control adjustment. The knob in the right is used to set the isobaric section. When this knob is turned, the dial hand turns in the same direction. The large numbers on the dial stand for cabin altitude in thousands of feet. The small numbers stand for the altitude of the plane in thousands of feet. For example: if the dial hand were set at 4 cabin pressure would be the same as atmospheric pressure at 4,000 feet. The plane, however, would be at approximately 30,000 feet, when the differential section caused cabin pressure to be vented out.

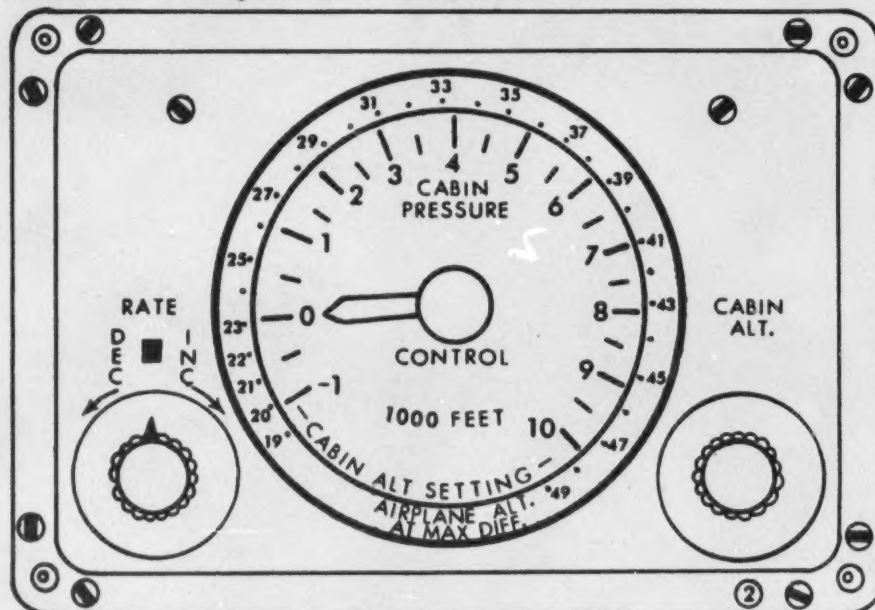


Figure 2. Automatic Controller.

Answer the statements as true (T) or false (F).

1. The knob in the left is the rate control adjustment.
2. The automatic controller is made up of an isobaric section, a rate control adjuster, and a differential section.
3. The knob in the right is used to set the differential.
4. The dial hand turns in the same direction as the cabin altitude knob.

2584

Correct Responses to Frame 2: 1. T, 2. T, 3. F, 4. T.

Frame 3

Now let us take a look inside the automatic controller. In figure 3 you can see the differential, rate control and isobaric sections. The only difference between these and similar sections you have learned, is in the isobaric section. This one can be set in flight. We will go to this feature in the next frame.

The numbers at the top of the diagram stand for: (1) filter and orifice, (2) cabin air inlet port, (3) atmospheric vent, and (4) the atmospheric pressure inlet to the differential.

Use figure 3 to complete the following statements.

1. The atmospheric inlet to the differential section is number _____.
2. A diaphragm separates atmospheric pressure from cabin pressure at the _____ section.
3. The _____ section is nothing more than an adjustable orifice.
4. The altitude selector knob is used to set the _____ section.
5. Port number 2 is the _____ port.
6. Cabin pressure goes in the controller through port number _____. To get to the isobaric section it must go through the _____ and _____ then the _____ section.
7. The atmospheric vent port is number _____.

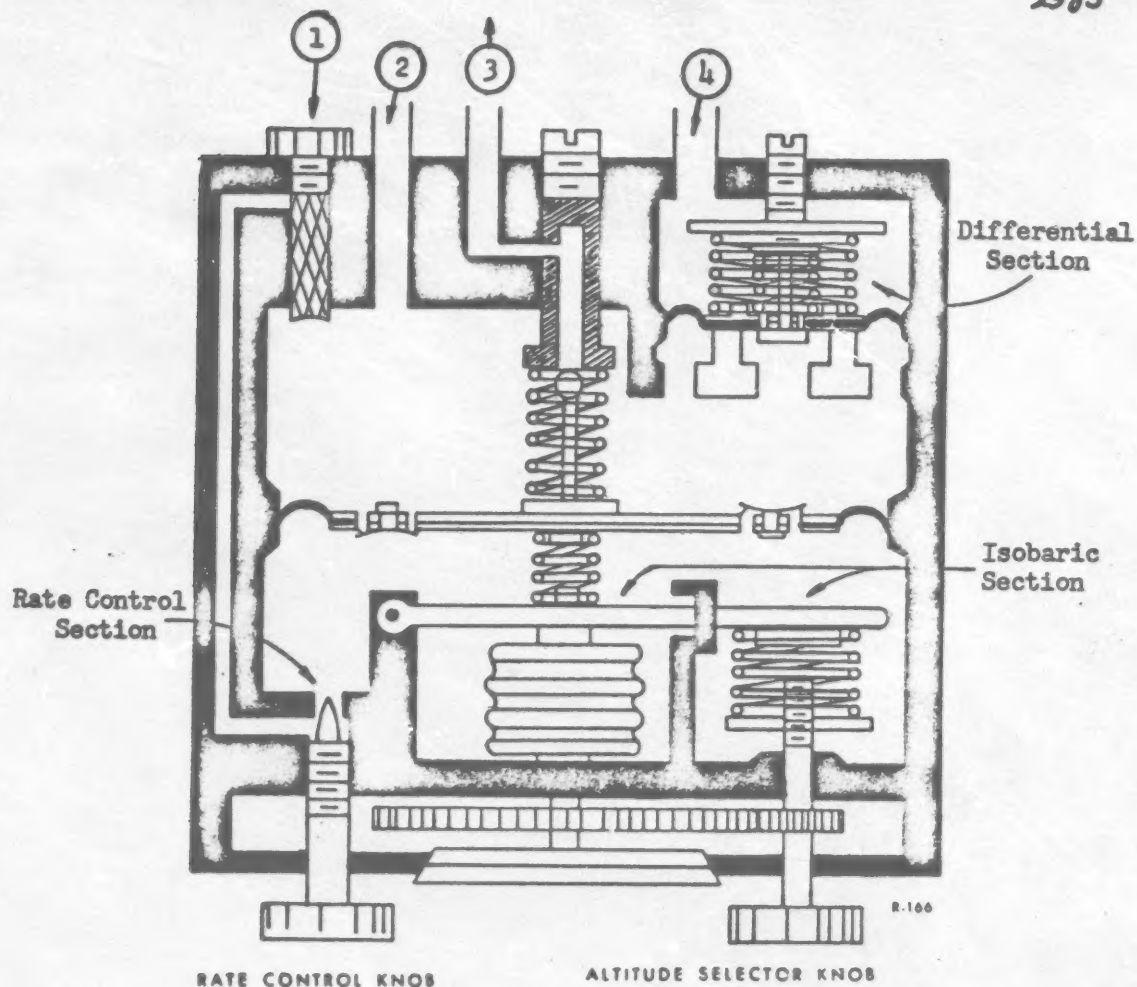


Figure 3. Automatic Controller.

2586

Correct Responses to Frame 3: 1. 4, 2. differential, 3. rate control, 4. isobaric, 5. cabin air inlet, 6. 2, filter, orifice, rate control, 7. 3.

Frame 4

Use figure 4. The isobaric section is made up of a lever, an aneroid, and adjustable spring. The aneroid is hooked to the lever that pivots on one end and rides on the spring at the other end. This means that all these parts must move together. When cabin pressure tries to squeeze the aneroid, the tension of the spring must be overcome before the lever can be pulled down. When the altitude selector knob is turned counter-clockwise the spring is squeezed between the lever and the nut that moves up on the selector knob shaft. When the selector knob is turned clockwise the nut moves down on the shaft increasing spring tension. The higher the spring tension, the higher the altitude at which cabin pressurization starts. The lower the spring tension, the lower the altitude at which cabin pressurization starts. Do not try to figure this out right now. We will explain what we mean in the next frame.

Answer the statements as true (T) or false (F).

1. The isobaric section is made up of a lever, an aneroid and adjustable spring.
2. Cabin pressure squeezes the aneroid against spring tension.
3. Tension on the spring is set by turning the altitude selector knob.
4. The aneroid, lever, and spring do not move together.
5. The lower the tension on the spring, the higher the altitude at which pressurization starts

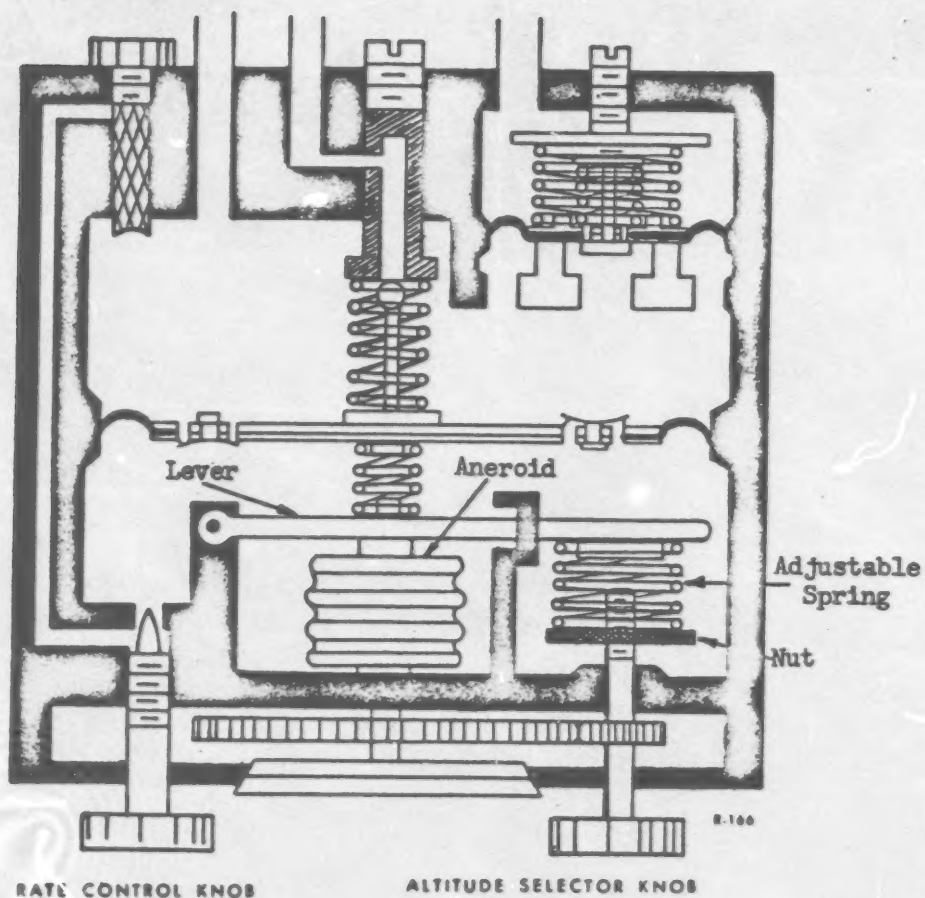


Figure 4. Automatic Controller.

Correct Responses to Frame 4: 1. T, 2. T, 3. T, 4. F, 5. F.

Frame 5

Use figure 5. Let us say the pilot wants his cabin pressurized to 8,000 feet in altitude (10.91 psia). He turns the altitude selector knob until the dial hand is on 8 (see figure 2). At this time the aneroid pressure (3 psia) and spring tension (7.91 lbs.) are the same as the atmospheric pressure at 8,000 feet (10.91 psia).

Keep in mind that when the plane is on the ground, atmospheric pressure (14.7 psia) would have the aneroid and spring (10.91 psia) squeezed flat. This means that as soon as the air conditioning system is turned on, the diaphragm will be pushed down and will open the vent valve. This lets the airflow to vent out to the atmosphere. Cabin pressure can not now build up.

Answer the statements as true (T) or false (F).

1. The pilot sets the desired cabin pressure by turning the rate control knob.
2. Pressure inside the aneroid is 3 psia.
3. Atmospheric pressure holds the vent valve on seat.
4. Cabin pressure must overcome the pressure in the aneroid and the adjustable spring tension before the vent valve will open.
5. The vent valve is closed and opened by the up and down movement of the diaphragm.

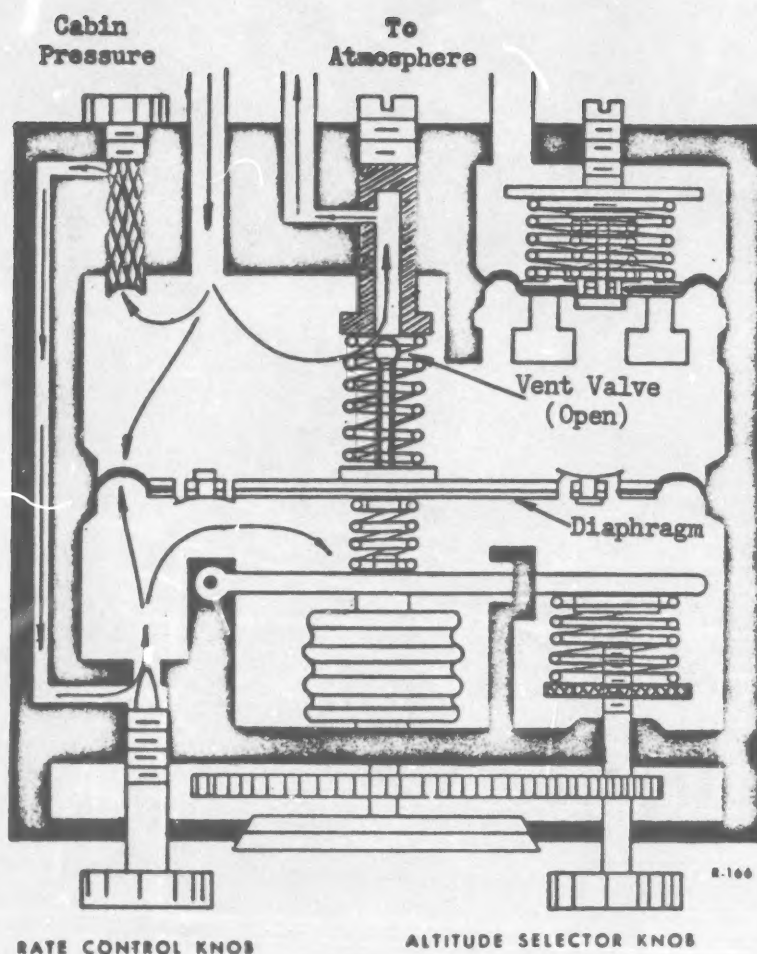


Figure 5. Automatic Controller.

Correct Responses to Frame 5: 1. F, 2. T, 3. F, 4. T, 5. T.

Frame 6

Use figure 6. A thing to keep in mind is that the automatic controller does not set cabin pressure. It is used to select an altitude at which cabin pressurization starts. So let us see how the isobaric section works as the plane starts to climb.

We have determined that with the controller set at 8, atmospheric pressure would have the aneroid squeezed and the vent valve would be open. We are now in the unpressurized range. At this time atmospheric pressure and cabin pressure are the same. As the plane climbs, atmospheric pressure drops. When the altitude of 8,000 feet is reached, cabin and atmospheric pressures drop below 10.91 psia. This pressure is on top of the controller diaphragm. At this point the aneroid and spring expand and push the vent valve ON seat. This lets cabin pressure build up. We are now in the isobaric range.

Answer the statements as true (T) or false (F).

1. The automatic controller automatically sets cabin pressure.
2. When the aneroid is squeezed, the vent valve will be open.
3. When the vent valve is open, cabin pressure cannot build up.
4. During the unpressurized range atmospheric pressure is more than cabin pressure.
5. The automatic controller is used to select an altitude at which pressurization starts.
6. Once the selected altitude is reached, the aneroid expands and the vent valve closes.
7. Cabin pressure will be automatically kept at the selected altitude in the isobaric range.

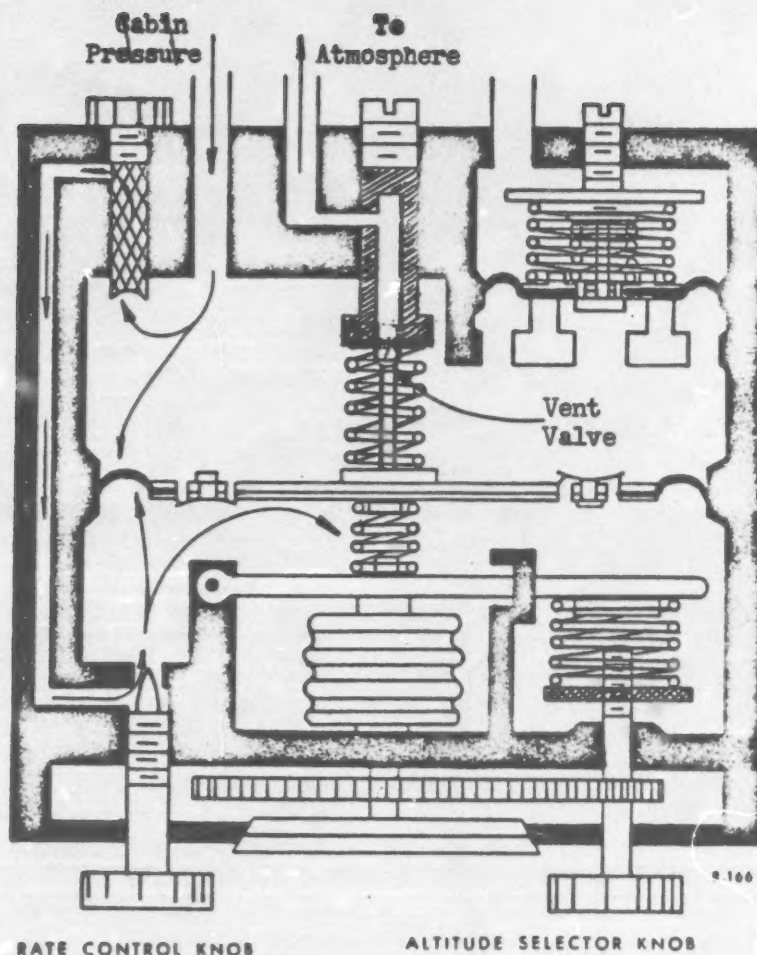


Figure 6. Automatic Controller.

Correct Responses to Frame 6: 1. F, 2. T, 3. T, 4. F, 5. T, 6. T, 7. T.

Frame 7

Use figure 7. In the isobaric range, the aneroid will continue to squeeze and expand. This will close and open the vent valve and automatically keep cabin pressure at the desired setting (in this case 10.91 psia and 8,000 feet).

The differential section is set to work at 8.1 psid. As the plane climbs, atmospheric pressure on top of the differential diaphragm drops. When cabin pressure on the bottom of the diaphragm is more than that on top (atmospheric pressure plus spring tension) by 8.1 psid, the diaphragm moves up. This will open a path to the atmosphere. Cabin pressure in the top of the controller now goes through the differential opening. The vent valve will go on seat and will cause the isobaric section to become ineffective. The plane is in the differential range with the differential section controlling cabin pressure. If the plane continues to climb, cabin pressure will drop. However, the differential section will keep a cabin pressure of 8.1 psid more than atmospheric pressure (while in the differential range), even though the altitude of the plane may change.

Answer the statements as true (T) or false (F).

1. In the isobaric range, operation of the aneroid automatically controls cabin pressure.
2. The differential section is set to work at 10.91 psid.
3. As aircraft altitude increases, atmospheric pressure drops.
4. Cabin pressure pushes the differential diaphragm up and atmospheric pressure plus spring tension pushes it down.
5. When the differential opens a path to the atmosphere, pressure underneath the controller diaphragm pushes the vent valve up and ON seat.
6. While in the differential range, cabin pressure will be kept at 8.1 psid more than atmospheric pressure even though the altitude of the plane may change.
7. During the differential range, if atmospheric pressure were 3.57 psia, cabin pressure would be 10.91 psia.

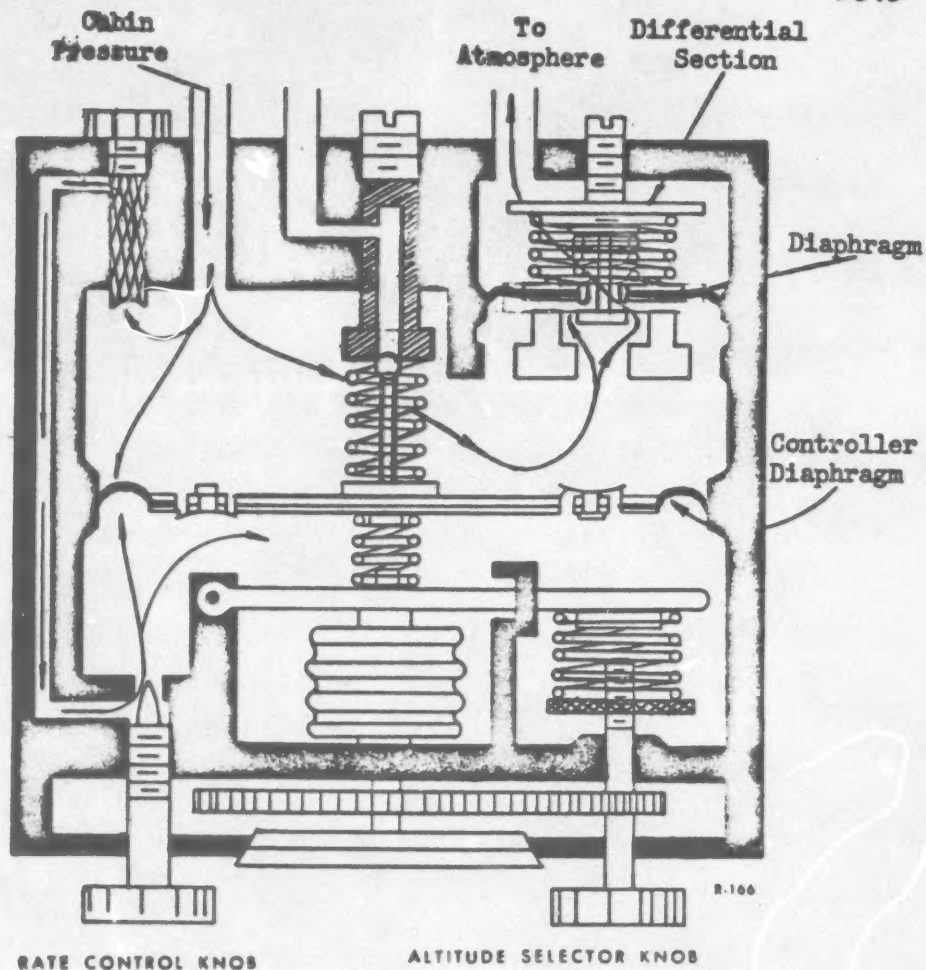


Figure 7. Automatic Controller.

Correct Responses to Frame 7: 1. T, 2. F, 3. T, 4. T, 5. T, 6. T, 7. F.

Frame 8

The C-141 aircraft is often used as a troop carrier. Sometimes the troops are hurt or ill and are flown to a hospital for treatment. The rate of change control section protects these people, as well as the flight crew, from a rapid fast rise in pressure. It does this by limiting the buildup of cabin pressure. The rate of pressure change is the same as a rise in altitude of between 200 and 2,000 feet per minute. Look at figure 5 as we give the operation of the rate control section.

Cabin pressure flows in the top of the controller, through the filter. Pressure flows past the adjustable rate control orifice, and in the bottom of the controller. Since the flow in the top chamber is not restricted, pressure builds up faster there than it does in the bottom chamber. The controller diaphragm is forced down, and pulls the vent valve open. This will let part of the cabin pressure to vent to the atmosphere. Soon the pressure in the lower chamber catches up and pushes the diaphragm up. This will close the vent valve. This whole process has limited the rate at which cabin pressure will build up.

If the orifice is opened all the way, the rise in cabin pressure will be at a rate that is the same as that of a 2,000 feet per minute altitude rise. The minimum is the same as a 200 feet per minute altitude rise. The pilot can change the size of the orifice by turning the rate control knob. He has a gage in the cockpit which shows him the rate of change in feet per minute.

Answer the statements as true (T) or false (F).

1. The rate of change control section protects personnel from a fast rise in pressure.
2. The rate control section can be set between 200 and 2,000 feet per minute rate of change.
3. Cabin pressure flows in the bottom of the controller faster than it flows in the top.
4. The rate control orifice is set when the pilot turns the rate control knob on the automatic controller.
5. When pressure in the lower chamber of the controller catches up with the pressure in the upper chamber, the vent valve will be forced ON seat.

Correct Responses to Frame 8: 1. T, 2. T, 3. F, 4. T, 5. T.

Frame 9

Look at figure 1 and find the manual controller. With this part the pilot can manually adjust and control cabin pressure if the automatic controller fails.

Follow each of the lines leaving the manual controller to see where they hook into the rest of the system.

NO RESPONSE REQUIRED

Correct Response to Frame 9: None Required.

Frame 10

Use figure 8. Due to the arrangement of the two cams, the inlet and outlet valves work at the same time, but in opposite directions. If the knob were turned clockwise (more pressure) the inlet valve would start to move OFF seat. The outlet valve would start to move ON seat. Keep in mind, the pilot uses this valve ONLY when the automatic controller fails, let us say the vent valve sticks on seat.

As the inlet valve opens, the outlet valve will close, restricting the amount of air that will vent overboard. This will cause cabin pressure to rise. To drop cabin pressure the pilot turns the knob counterclockwise and the valves move just the opposite as before. The idea is for the pilot to get the valves set just right so that cabin pressure is kept at a desired rate.

Answer the statements as true (T) or false (F).

1. The inlet and outlet valves work at the same time.
2. Cabin pressure enters the manual controller through the filter and orifice.
3. If the knob were turned clockwise, cabin pressure would drop.
4. The manual controller is used to aid the automatic controller in dumping cabin pressure.
5. Cabin pressure must go through the manual controller to get to the automatic controller.

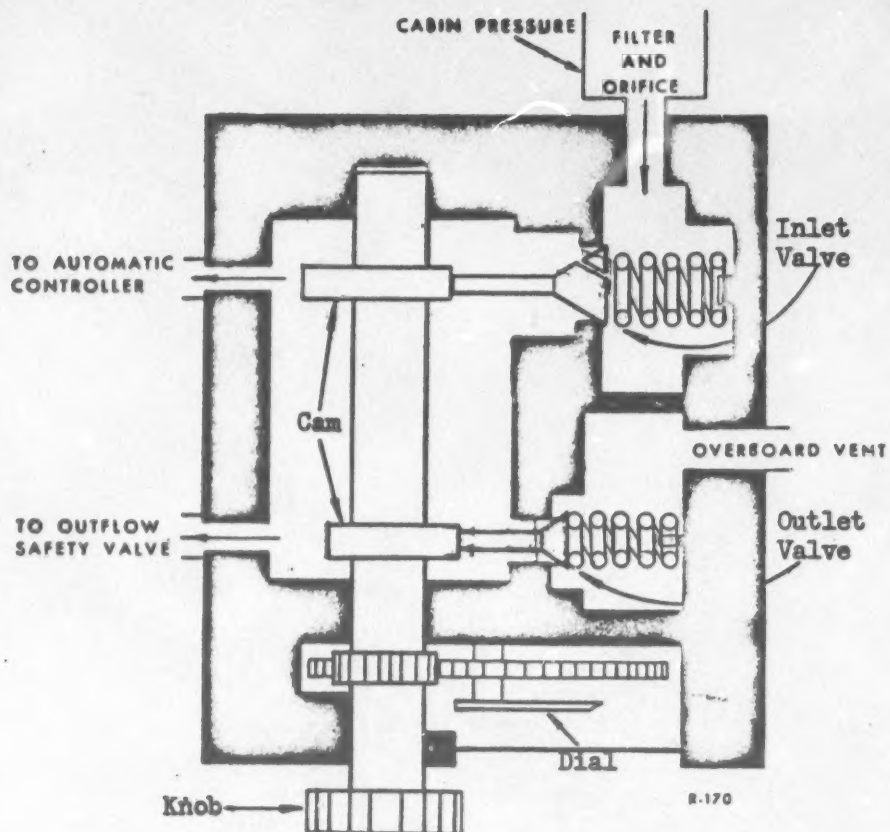


Figure 8. Automatic Controller.

Correct Responses to Frame 10: 1. T, 2. T, 3. F, 4. F, 5. T.

Frame 11

Take a look at the schematic on foldout 1 and find the outflow/safety valve. This valve has several parts important to the function of the pressurization system. The first of these parts that we will discuss is the pneumatic relay. It is placed in the upper left corner of the outflow/safety valve. The job of the relay is to cause a fast response of the outflow valve when the vent valve in the automatic controller opens. Here is how it works.

When the vent valve is opened, cabin pressure in the top of the automatic controller will vent to the atmosphere. Look at the schematic and follow the arrows from the relay. If you will recall Pascals' Law, you can see that when pressure drops in the top of the controller, it drops the same amount in the top of the relay and at the same time. Both chambers have the same confined air. When just a small amount of pressure is dumped from the top of the relay, head pressure will push the relay diaphragm up and opens the needle valve. Head pressure will now vent to the atmosphere through the passageway out of the bottom of the outflow/safety valve. Cabin pressure lifts the outflow valve off seat and vents to the atmosphere.

Answer the statements as true (T) or false (F).

1. The pneumatic relay causes a faster response of the outflow valve when the vent valve opens in the automatic controller.
2. Pressure in the top of the pneumatic relay is the same as that in the top of the automatic controller.
3. Head pressure lifts the outflow valve off seat.
4. A large amount of pressure must be relieved on top of the relay before the needle valve is lifted off seat.
5. When the relay needle valve is moved off seat, head pressure is vented to the atmosphere and the outflow valve opens.

Correct Responses to Frame 11: 1. T, 2. T, 3. F, 4. F, 5. T.

Frame 12

A jet pump is placed in the outflow/safety valve to help the relay open the outflow valve quick. Look at figure 9. The jet pump works like a venturi. As engine bleed air (regulated to 16 psi) is forced through the pump, air speed will rise. Pressure will drop where the passageway is the smallest. This tends to suck the head pressure out past the relay needle valve that will cause the outflow valve to open immediately. Keep in mind, this will all happen when the vent valve in the automatic controller comes off seat.

Number each of the events in the order in which it takes place.

- ___ a. Cabin pressure will open the outflow valve and vent to the atmosphere.
- ___ b. The vent valve in the automatic controller will open when cabin pressure overcomes the setting of the isobaric aneroid.
- ___ c. The relay needle valve opens to let head pressure to be sucked out by the jet pump.
- ___ d. Pressure on top of the relay diaphragm is dumped through the manual controller and out the vent valve in the automatic controller.

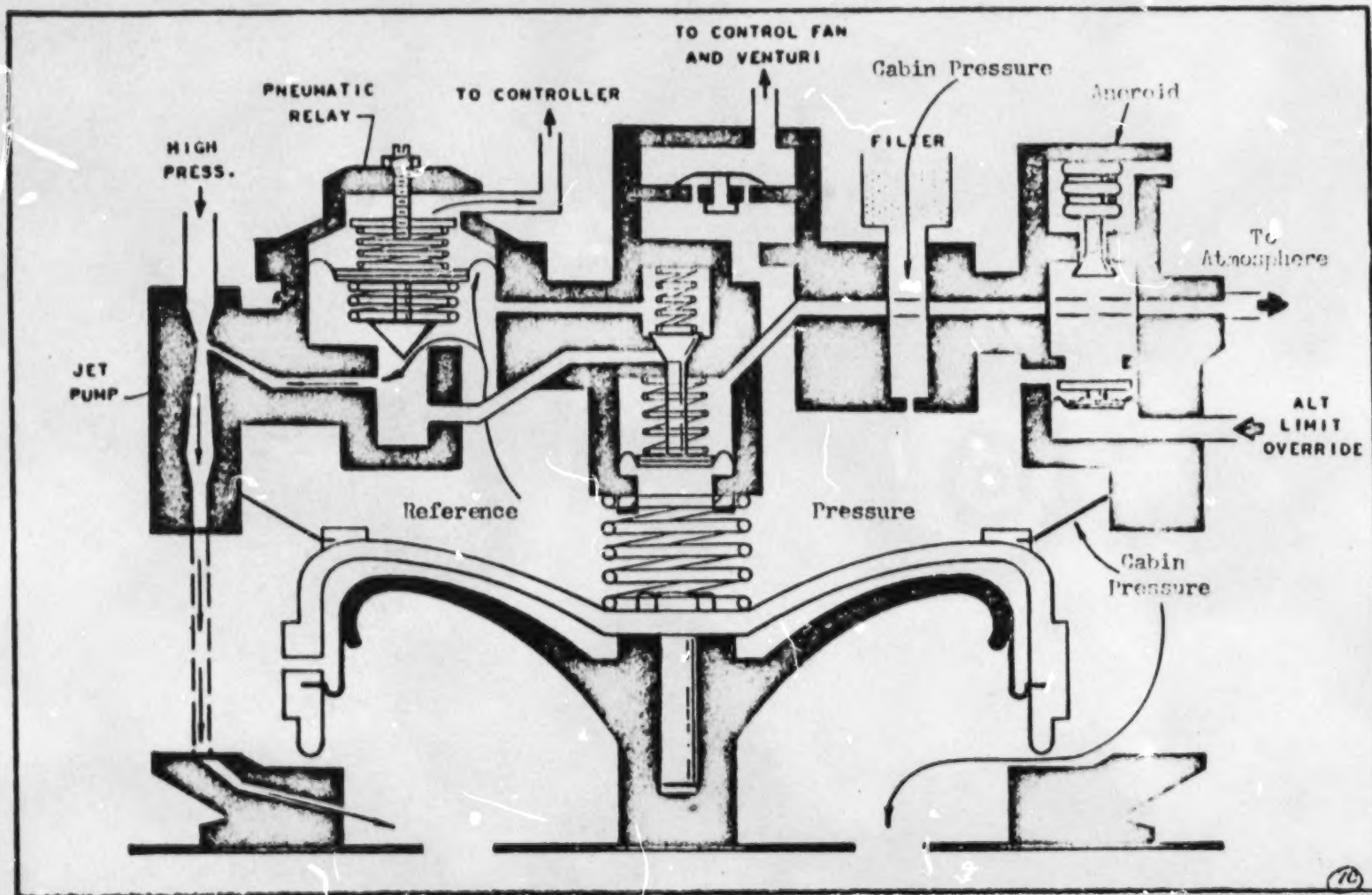


Figure 9.

Correct Responses to Frame 12: 4 a. 1 b. 3 c. 2 d.

Frame 13

The safety valve protects the plane and flight crew from too much cabin pressure if the differential section fails to work. The differential section is supposed to work at 8.1 psid. If it does not, the safety valve will open at 8.6 psid.

Look at figure 10 and see that atmospheric pressure is on top of the safety valve diaphragm. If head pressure underneath the diaphragm is 8.6 psid more than the atmospheric pressure on top, the diaphragm is forced up and the safety valve will open. Head pressure rushes past the opened safety valve to the jet pump. Here it is sucked out and vented overboard. Cabin pressure will push the outflow valve open and vent to the atmosphere.

Answer the statements as true (T) or false (F).

1. If the differential section fails, the safety valve will control cabin pressure and keep it at 8.1 psid.
2. Atmospheric pressure is acting on top of the safety valve diaphragm.
3. Once the safety valve is opened, head pressure is dumped rapidly due to the work of the jet pump.
4. Cabin pressure opens the outflow valve when head pressure exceeds atmospheric pressure by 8.6 psid.
5. The job of the safety valve is to protect the plane and flight crew from too much cabin pressure.

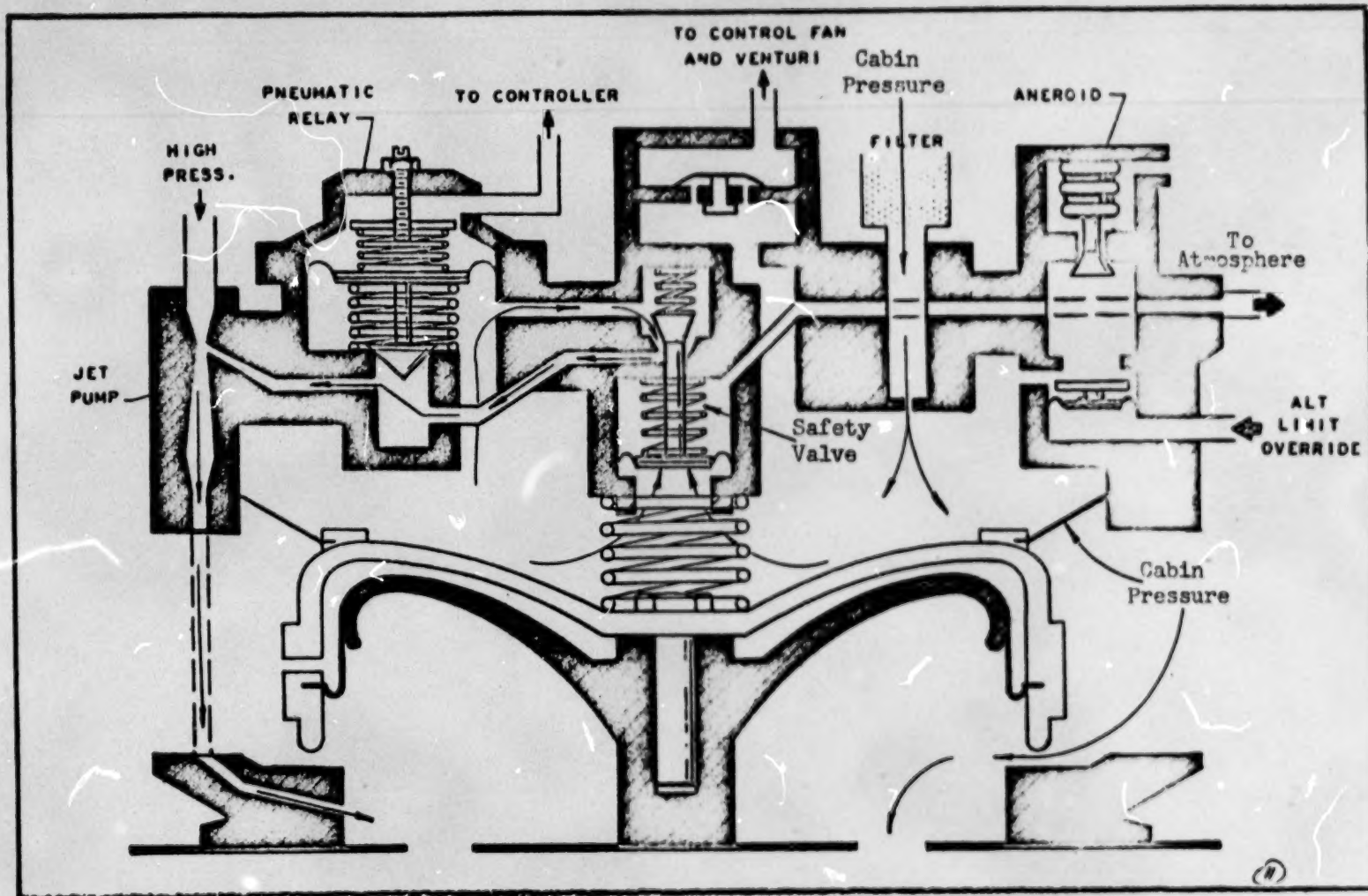


Figure 10.

773

772

Correct Responses to Frame 13: 1. F, 2. T, 3. T, 4. T, 5. T.

Frame 14

We just learned how the C-141 safety valve protects the flight crew and passengers from too much cabin pressure. The plane also has a feature which makes sure that cabin pressure does not get too low. This feature is provided by the aneroid and override valve shown in the top right corner of figure 11. The aneroid has 8.81 psia. As long as the system is in the normal mode of operation, it is kept squeezed by cabin pressure. Let us find out when and how it expands and what happens when it does.

Suppose the pilot has the automatic controller set at 8 and the plane is flying at 40,000 feet. This means cabin pressure will be kept at 10.91 psia. If, for some reason, the vent valve in the automatic controller opened or started to leak, the relay would open the dump head pressure. This would let the outflow valve open and cabin pressure would start to drop. When the pressure drops to 8.81 psia, the aneroid will expand and open an additional path for cabin pressure to go to the top of the outflow diaphragm. Due to this additional path, cabin pressure will now go in the head pressure chamber faster than it can leak out. This will cause the outflow valve to close and keep cabin pressure from dropping to 2.73 psia (atmospheric pressure at 40,000 feet). The aneroid will continue to open and close to control cabin pressure at 8.81 psia that is the same as a 13,500 feet altitude.

If, however, the pilot wants cabin pressure to be lower than 8.81 psia, he sets an override switch that is on his control panel. This will cause solenoid valve #2 (see foldout 1) to open. Engine bleed air is then sent to the bottom of the override valve. The override valve will close and make the aneroid operation ineffective. Now, the pilot can open solenoid valve #1 or the manual controller and drop cabin pressure as low as he wants it. This procedure would need to be used in paratroop or cargo drops when atmospheric pressure is less than 8.81 psia. To make these drops the cargo doors have to be opened. The pilot would want to lower cabin pressure gradually until it is the same as atmospheric pressure. If he did not drop cabin pressure beforehand, there would be such a fast decompression when the cargo doors were opened that the cargo and personnel alike would possibly be blown out of the opening.

Answer the statements as true (T) or false (F).

1. The small aneroid keeps cabin pressure from becoming too high.
2. The override valve is closed by engine bleed air.
3. The aneroid has 8.81 psia.
4. When the aneroid expands, cabin pressure comes in the head pressure chamber faster than it can get out and the outflow valve will close.
5. Unless the override valve is closed, the aneroid will keep cabin altitude to 13,500 feet.

2604

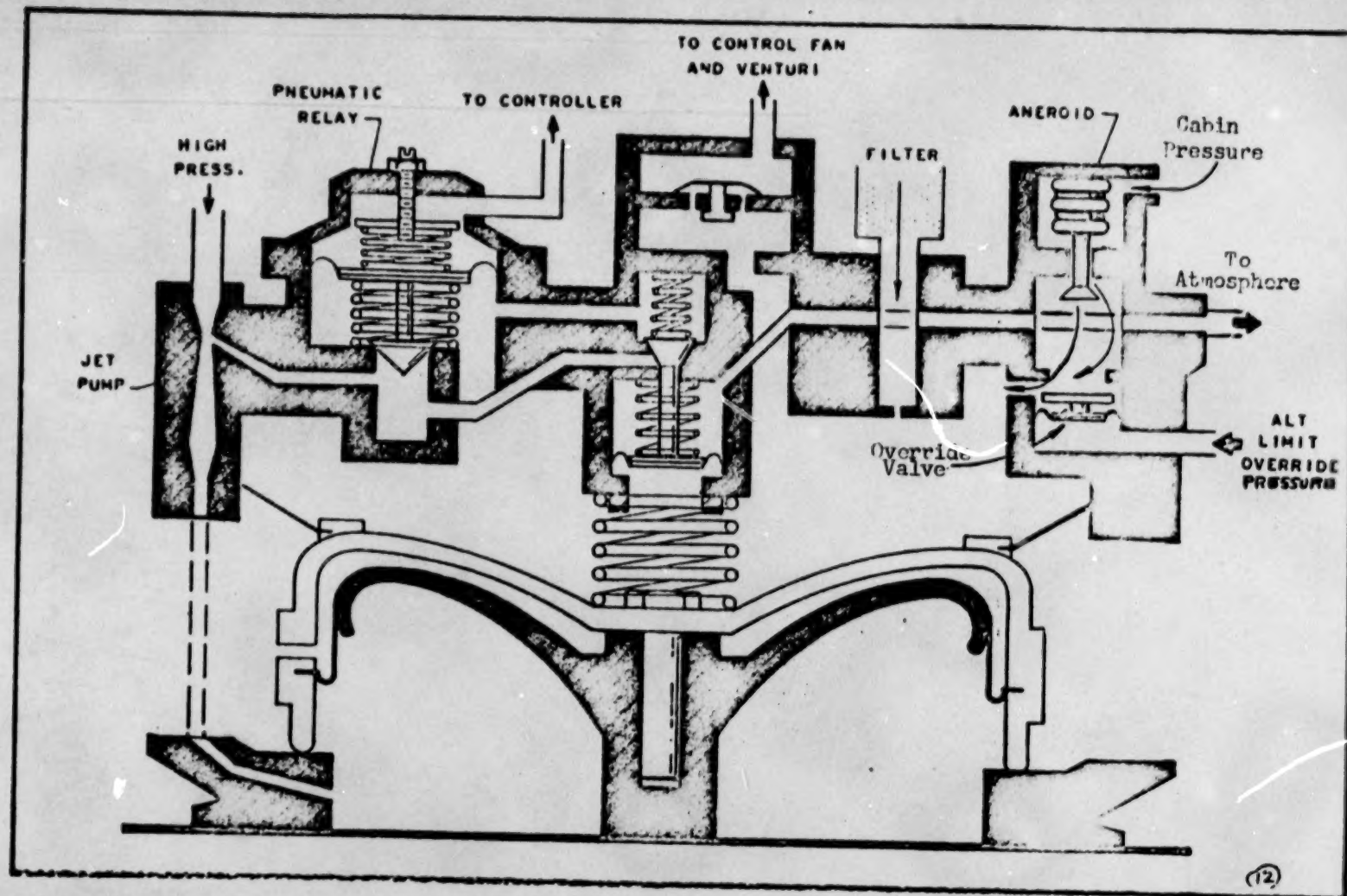


Figure 11.

776

775

24

(12)

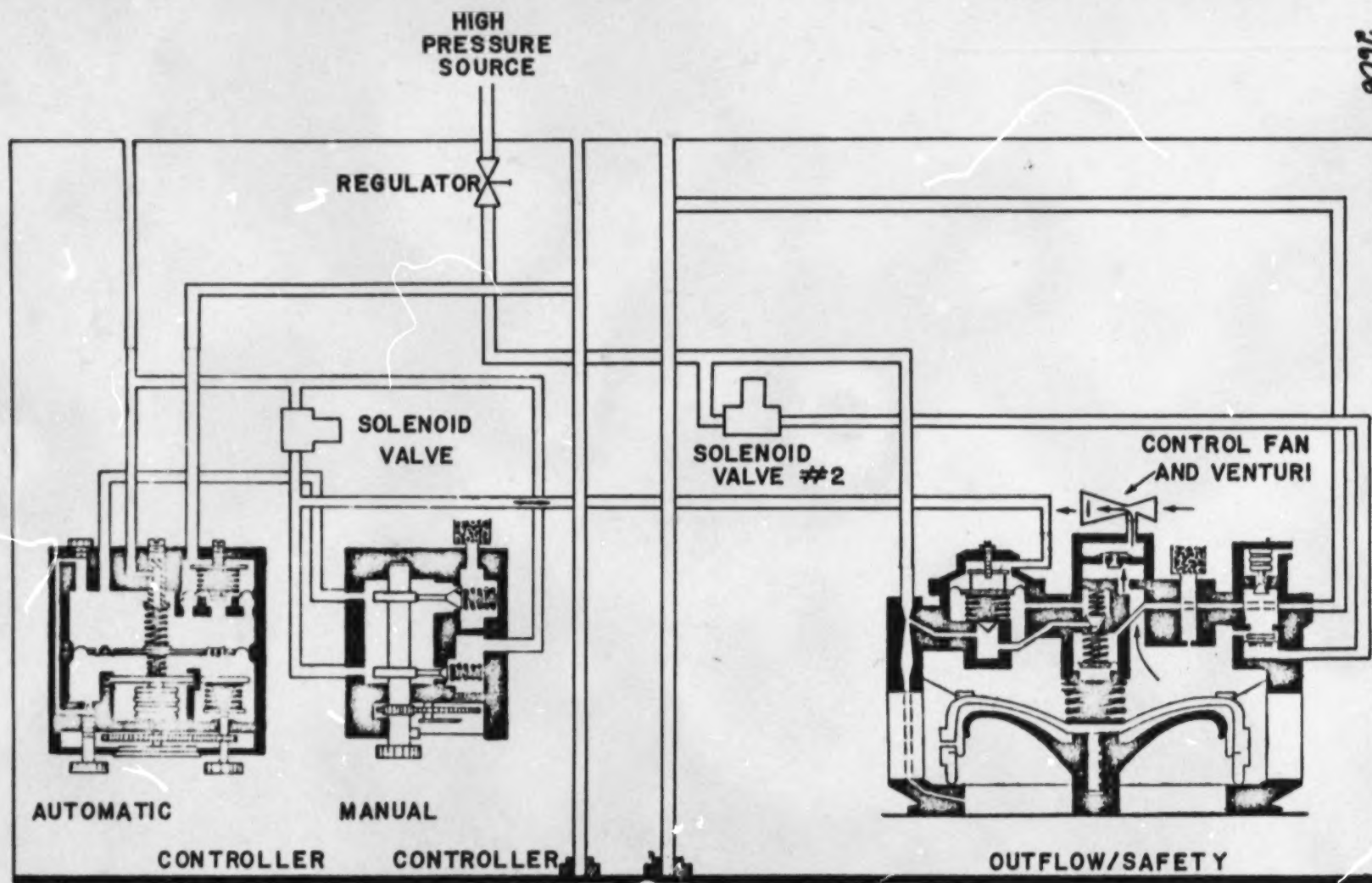
Correct Responses to Frame 14: 1. F, 2. T, 3. T, 4. T, 5. T.

Frame 15

When the C-141 aircraft lands, the outflow valve opens automatically to let cabin pressure equalize with the atmospheric pressure. A squat switch on the landing gear shock strut (when the weight of the plane sets on it) turns on the control fan shown in figure 12. The fan draws air through a venturi creating a low pressure or suction. This pulls the small diaphragm open and vents head pressure overboard. The outflow valve opens allowing cabin and atmospheric pressures to be the same.

NO RESPONSE REQUIRED

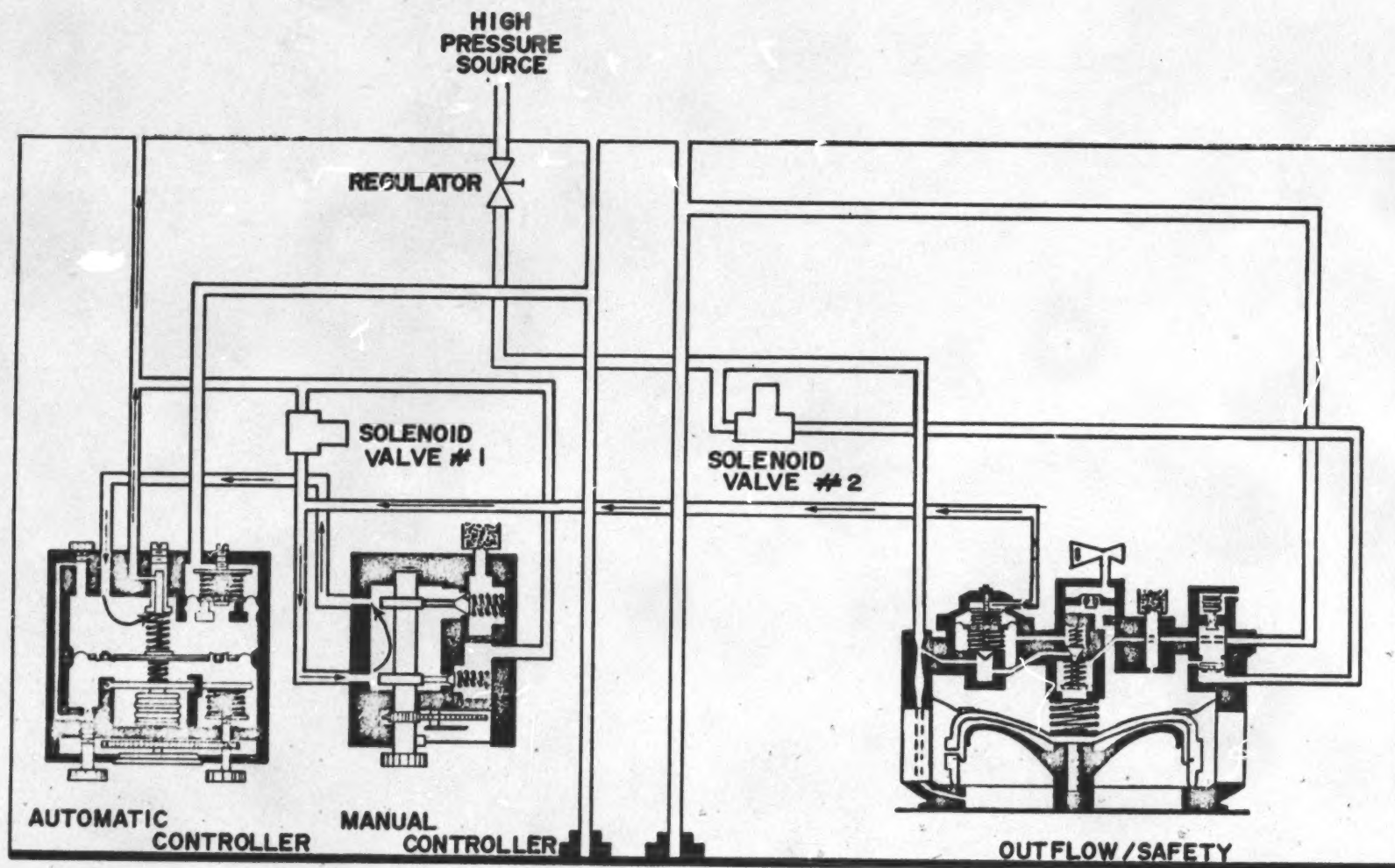
Figure 11.



778

Figure 12.

779



780

781



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WORKBOOK

3ABR42231-WB- 316

Technical Training

Aircraft Environmental Systems Repairman

OPERATION OF MB-3 LEAKAGE TESTER

16 October 1975



USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3343rd Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

Environmental Pseudraulic Branch
Chanute AFB, Illinois

3ABR42231-WB-317

OPERATION OF MB-3 LEAKAGE TESTER

OBJECTIVES

After completing this programmed text, you will be familiar with the operation of the MB-3 cabin leakage tester. To aid you in this, you will be required to:

1. Interpret instructions in the proper technical order.
2. Identify leakage tester components and explain their function.

Standard of performance:

You must complete this project with 70% accuracy.

EQUIPMENT

TO 33A4-4-10-1

Basis of Issue
1/student

PROCEDURE

This package presents information to you in the form of questions and incomplete statements. Read the TO closely, answer the questions and complete the statements by writing the necessary information in the blank spaces provided. CAUTION: Don't just skim through the TO looking for key words or phrases that help you find the answers. Study the information in the TO and make sure you understand it. In the very next lesson you will be required to pressurize an aircraft cabin using this tester. So, learn the material well now and save yourself some time later on.

Take TO 33A4-4-10-1 from the file and open it to section I.

1. What is the name of the company that makes the MB-3 cabin leakage tester? _____

2. The tester is designed to supply _____ to aircraft cabins at _____ for _____ under _____.

Supersedes 3ABR42231-WB-317, 19 July 1973.

OPR: TAS

DISTRIBUTION: X

TAS - 500; TTVGC - 2

3. How much air and pressure is the tester capable of producing?

4. Is the tester suitable for use under world-wide climatic conditions? _____

5. The instrument panel contains instrumentation to indicate

_____, _____,

_____, _____

_____ and _____,

and _____.

6. The tester is shipped wired for _____ volt service.

Note: Complete the following statements, then check figure 4-1 in the TO to locate items 7 through 16 on the leakage tester.

7. The blower pressure gage indicates _____

_____ of the blower.

8. The cabin pressure gage indicates _____

_____ of the aircraft under test.

9. The rate of cabin pressure change indicator is a standard

_____ with a special dial to

indicate _____ or _____ pressures rather

than _____ or _____.

10. What is the purpose of the air temperature indicator? _____

11. What does the canopy seal pressure indicator show? _____

2611

12. What is another name for the cabin pressure regulator? _____

13. What does it control? _____

14. The canopy seal air regulator _____

15. How is the dump valve operated? _____

16. What does the flowmeter do? _____

17. Refer to figure 1 in this text and figure 4-1 in the TO and label the components represented by a letter.

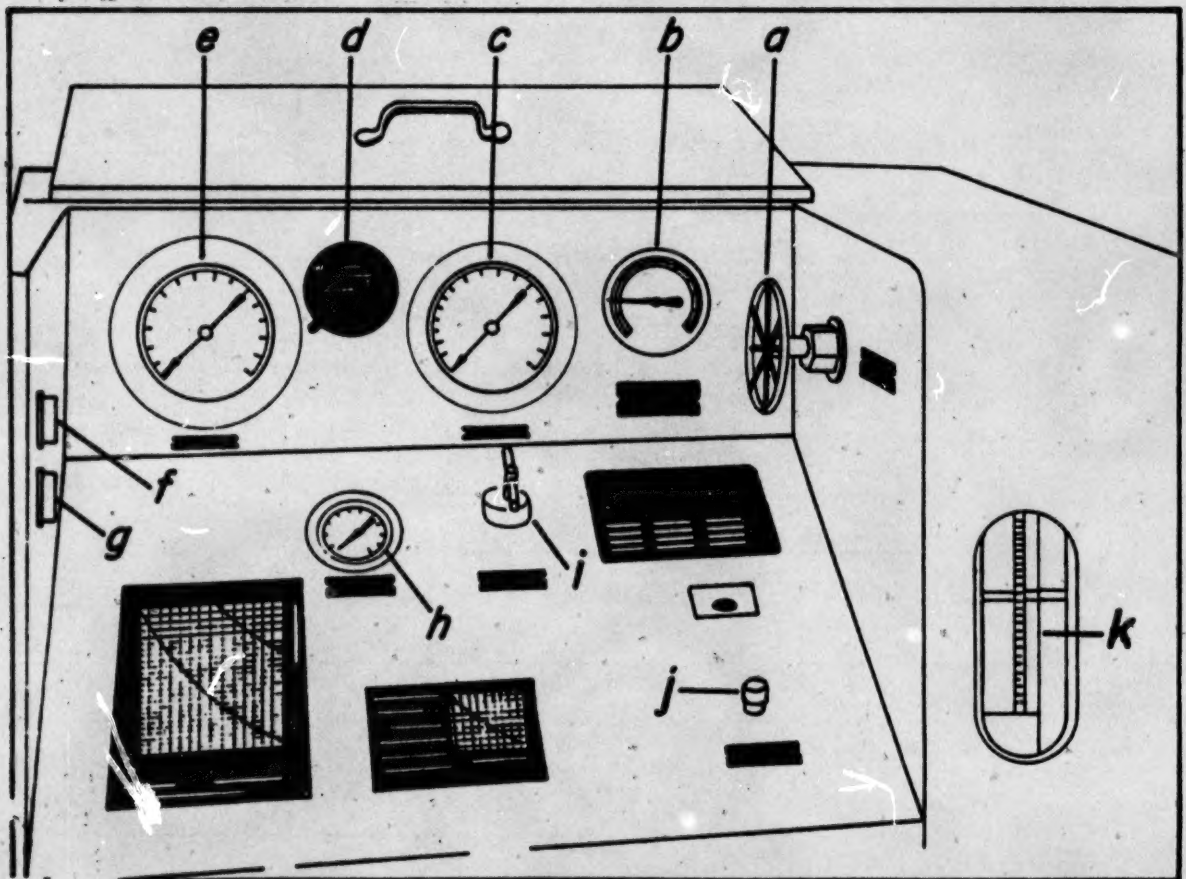


Figure-1. MB-3 Instrument Panel.

- a. _____.
- b. _____.
- c. _____.
- d. _____.
- e. _____.
- f. _____.
- g. _____.
- h. _____.
- i. _____.
- j. _____.
- k. _____.

18. On the flowmeter (TO figure 4-2) blower pressure is represented by _____ which are numbered at _____ from _____ to _____.

19. What do the diagonal or curved lines on the flowmeter represent?

20. The flowmeter is calibrated for an air temperature of _____.

Note: Refer to starting instructions in the TO to find the correct setting (prior to starting) for the following items.

21. Turn the dump valve _____ to the _____ position.

22. Turn the canopy seal air regulator _____ until control feels _____.

23. Turn the cabin pressure regulator knob _____ or _____ as required until the desired _____ is indicated on the _____ dial.

2613

Note: The most common procedure is to turn the regulator counter-clockwise to minimum prior to starting of the tester.

24. What is the next step in starting the tester? _____

25. Adjust canopy seal pressure by turning the _____
_____ clockwise until the
_____ indicates the desired pressure.

Note: The maintenance manual of the aircraft under test would give the canopy seal pressure.

26. Turn _____ valve _____ slowly
to the _____ position.

27. Why are the red lines on the rate of cabin pressure change
gage? _____

28. Make final readjustment of _____
with _____ pressure
adjustment. Read _____ on cabin
pressure gage.

29. When operating the tester, the operator should not _____
_____ and
should constantly observe the _____,
_____, _____ and
_____ reading.

30. Set the cabin pressure regulator to proper pressure relief
indication. This will be determined by _____
_____ being tested.

787

31. What is the next step? _____
32. Will the blower pressure gage and the cabin pressure gage read the same while the tester is being adjusted? _____
33. What instrument do you use to determine the amount of cabin leakage? _____
34. At this point turn to TO figure 4-2 and make sure you know how to read the flowmeter. Are the psi and cfm readings shown at the left in figure 4-2 correct? _____
35. With the float in the position shown in figure 4-2, how much would the aircraft cabin be leaking if blower pressure was 9.5 psi? _____
What if blower pressure was 7.5 psi? _____
36. If you can't answer questions 34 and 35, refer to TO paragraph 4-7 to learn how to read the flowmeter.
37. Study TO paragraph 4-9 closely and answer the following questions.
38. What do the vertical lines on the chart in TO figure 4-3 represent? _____
39. What is TO figure 4-3? _____
40. When does this chart have to be used? _____
41. Let's say the flowmeter indicates an airflow of 130 cfm and the temperature gage reads 140°F. What is the corrected flow value? _____
42. Study TO paragraph 4-10 closely and answer the following questions.
43. What is the approximate weight of one cubic foot of air at 70°F and 14.7 psia? _____
44. Take the answer that you got for question 41 and convert it to pounds per minute by the method outlined in TO paragraph 4-10. What is your answer? _____

2615

45. If your answer is not 9.165 ppm you have made a mistake. Go back to question 41 and try again.

46. If the air temperature should exceed 150°F or if barometric pressure was something other than 14.7 psia, you would have to use the chart shown in TO figure 4-4 to convert cfm to ppm. We won't have you learn this chart since most all aircraft TOs limit air temperature for leakage tests to 120°F.

47. What is the first step in stopping the cabin pressure tester?

48. When _____ reading is down,
stop _____ motor by _____
stop button.

49. Turn the _____ air regulator _____
_____ until the control feels _____
_____.

Note: After you have completed this workbook, return it to the instructor for grading.



Technical Training

Aircraft Environmental System Mechanic

CABIN PRESSURE LEAKAGE CHECK

18 September 1975



CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR42231-SW-317, 20 February 1973.

OPR: TAS

DISTRIBUTION: X

TAS - 150; TTVGC - 2

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The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

The STUDY GUIDE AND WORKBOOK (SW) contains both SG and WB material under one cover. The two training publications may be combined when the WB is not designed for you to write in, or when both SG and WB are issued for you to keep.

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CABIN PRESSURE LEAKAGE CHECK

OBJECTIVES

After completing this study guide/workbook you will be able to perform a cabin pressure leakage check of an aircraft cabin. To enable you to do this, you will be required to:

1. Operate the MB-3 Leakage Tester.
2. Follow safety precautions applicable to pressurization.
3. Interpret instructions in technical manuals.

Standard of performance:

You will be evaluated by an instructor who will observe your performance and administer a criterion referenced test. You must complete this project with 70% accuracy.

EQUIPMENT

	Basis of Issue
CT-5, F-111 Trainer	1/8 students
MB-3 Cabin Leakage Tester	1/8 students
Intercom Headset	1/student
Applicable Handtools	1/student
TO 1F-111A-2-2-1	1/student
TO 33A4-4-10-1	1/student

INTRODUCTION

You have learned that some aircraft compartments are pressurized so that a flight crew can sustain life and function effectively at high altitudes. One of the jobs of the Environmental Systems Repairman is to check the cockpits and/or cabins of various aircraft for too much pressure leakage. We say "too much" because the airplane is made to allow for some leakage for ventilation. The flow of air from the environmental system (the cooling turbine) is more than enough to keep the selected cabin pressure at all altitudes and flight conditions. Sometimes the leakage is so great that the air supply cannot keep up and cabin pressurization is lost. When this happens, the Environmental Systems Repairman must find the leak and repair it if possible. It is sometimes hard to find an air leak and practically impossible with the aircraft in flight. Therefore, cabin pressure leakage checks are made on the ground using a cabin leakage tester to simplify this difficult task.

PROCEDURE

Before a cabin pressure leakage test is made, you should familiarize yourself with the steps listed in the Technical Order.

26/9

To do this we will have you use the TO to answer some questions about the cost. After this is done, tell the instructor that you are ready to make a cabin pressure leakage test.

Now, get TO 1F-111A-2-2-1 from the file and answer the questions and complete the following statements:

Caution: The pressure leakage test is hazardous. Be sure you know each step before you go to the next.

1. Which section of the TO is for the cabin pressure leakage checkout? _____
 - a. Turn to the correct section.
 - b. On which page does the section start? _____.
2. The cabin pressure leakage checkout section gives maintenance personnel the instructions for pressure-testing the cabin after maintenance on the windshield, _____.
3. No personnel shall be in the cabin when _____.
4. _____ shall remain stationed at the cabin leakage tester at all times while the cabin is being pressurized.
5. _____ will be put on prior to pressurizing the cabin to _____.
6. The cabin pressure leakage checkout consists of _____.
7. What type of cabin leakage tester is used to make the checkout? _____.
8. The leakage tester shall be placed at _____ in direction away from the aircraft _____ area.
9. Cut the lockwire and remove the cap; then connect the canopy seal hose to _____ in the nose wheel wall.

10. Take care when connecting the cabin leakage tester to the aircraft to prevent _____.

11. _____ and remove the cap; then connect the air supply hose to _____.

12. How many hoses will be connected to the aircraft?
_____.

13. Turn the dump valve on the leakage tester _____ to full _____ position.

14. Slowly turn _____ on the leakage tester _____ until a test pressure of _____ is shown on _____.

15. Normal leakage will vary between the aircraft, and _____ shall be held _____ to keep cabin _____.

16. Allow the system time to stabilize between _____ to avoid exceeding _____ at any time.

17. When the pressure rate-of-change gage reads zero, cabin pressure should be stabilized at how much? _____.

18. What does the abbreviation (scfm) mean? _____.

19. New aircraft can have a leakage rate of _____ scfm. Leakage will _____ as the aircraft is flown when _____; however, _____ leakage of serviceable aircraft is less than _____ scfm.

20. If the cabin has too much leakage, which section of the TO refers to leakage repair? _____.

21. What substance should be used to find leaks during air pressure testing? _____.

22. Do not allow the rate of decrease in altitude to exceed _____ per minute.

23. The last step before you close and secure the forward equipment bay aft door is to _____ and lockwire.

Note: When you have done this part of the text, tell the instructor you are ready to make a pressure leakage test. He may have you wait for awhile until at least one other person is ready to make a test, since the job needs two people.

When the instructor gives you the OK to make a leakage test, do each of the steps in order.

1. Make sure that at least ONE person in your group has a copy of TO 1F-111A-2-2-1 and TO 33A4-4-10-1.

2. Go to room A-106 and tell the instructor that you are ready to make a leakage test. He will give you a toolbox.

Note: WORK AS A TEAM. Each of you make sure all steps are done PROPERLY and SAFELY.

3. The outside of both doors in room A-106 have folding yellow signs. UNFOLD and LATCH the signs so that outsiders will know that a pressurization check is in progress.

4. On the cabin trainer side facing the door of room A-106, you will see steps that are used to get in and out of the cockpit. To the right and below the steps, you will find two capped ports. One port is labeled CANOPY SEAL TEST and the other COCKPIT PRESSURE. About two feet to the right and just above these ports you will see a third port which is labeled CABIN LEAKAGE TEST. The Tester hoses will be connected to these three ports when you reach that point in the test. (NOT NOW)...

5. To the left of the steps is a white circuit breaker box. Behind and to the right of this box are two ports mounted on the cabin bulkhead. The cabin pressure regulator discharge port is labeled COMBAT and the schedule test port is labeled NORMAL.

Note: All five ports are in the nose wheel well on the aircraft.

6. Remove the vent caps and put an unvented test cap on the NORMAL port and one on the COMBAT discharge port, snug each cap gently with a wrench (the unvented test caps are kept in the toolbox). Read the NOTE in Section X, paragraph 10-18a, of TO 1F-111A-2-2-1, to understand why unvented test caps must be used. As far as we know, the F-111 is the only aircraft on which these ports are capped for leakage testing. On most planes a lever on the cabin pressure regulator is turned to shut off these ports.

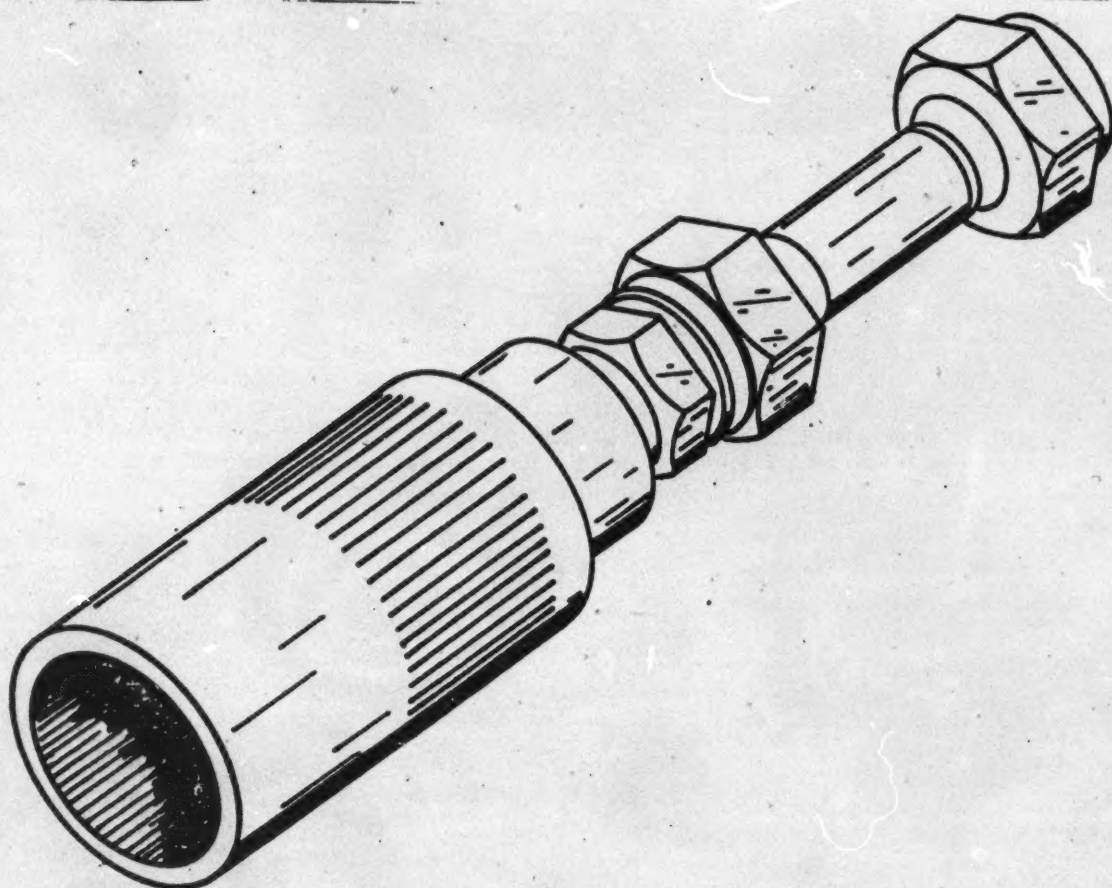


Figure 1. Hose Adapter.

7. Take the hose adapter (figure 1) from the toolbox and put it on the CABIN LEAKAGE TEST port. Do not lose the cap that you remove from this port. Tighten the adapter connection with a wrench; just tight enough so that it will not leak when the trainer cabin is pressurized.

8. Remove the hoses from the top of the tester cabinet.

9. Connect one end of the large cotton hose to the hose adapter on the trainer and the other end to the brass air outlet connection on the tester. Get two hose clamps from the toolbox and use them to secure the large hose so that it will not leak.

10. Connect the CANOPY SEAL hose to the tester and to the CANOPY SEAL TEST port on the trainer. Snug the fittings with a wrench.

11. Connect the CABIN PRESSURE hose to the tester and to the CABIN PRESSURE GAGE port on the trainer. Snug the fittings with a wrench.

Note: The tester should be placed so that each hose is STRAIGHT and FLAT on the floor.

12. Close and latch both cabin hatches. CAUTION: MAKE SURE NO ONE HAS HIS HANDS IN THE WAY.

13. Place the SAFETY NET and secure it to the frame of the trainer. Make sure all glass areas are covered (the net should be placed so that it looks like that shown in figure 11-2 of TO 1F-111A-2-2-1). The single strap with a metal tab on it is placed on top and to the aft of the cabin. The metal tab fits over the head of the bolt at the rear of the cabin.

14. Connect the TESTER POWER cable to the 220V AC outlet, on the laboratory wall.

15. Open the instrument panel door. Open doors on the trainer, that TO 1F-111A-2-2-1 states should be open.

Note: You have been taught how to operate the MB-3 cabin leakage tester. If you do not remember, read section IV of TO 33A4-4-10-1. Do not take chances...make sure you KNOW what you are to do. An operator must be at the cabin tester at all times while the cabin is pressurized. Decide among yourselves who the OPERATOR will be; HE IS THE ONE THAT WILL OPERATE THE TESTER.

16. Turn the DUMP VALVE to full open.

17. Turn the canopy seal air regulator counterclockwise until the control feels slightly loose.

18. Turn the CABIN PRESSURE ADJUSTMENT knob COUNTERCLOCKWISE until a minimum pressure of 2 psi shows on the regulator dial.

19. Everyone put on a headset and plug it into one of the intercom jacks. The jacks are on the white power box at the front of the trainer. Use the headset when you want to talk with the instructor and the other students.

Caution: Do not unlatch the hatches while the cabin is pressurized.

20. Push the start button to start the tester.

21. Slowly adjust the CANOPY SEAL AIR REGULATOR until 50 to 60 psi shows on the CANOPY SEAL PRESSURE GAGE. The canopy seal will inflate and stop leakage from around the canopy hatches.

22. Slowly turn the tester DUMP VALVE CLOCKWISE to the full closed position. Air will flow to pressurize the cabin.

Caution: Watch the pressure RATE OF CHANGE gage to make sure you DO NOT cause more than a 5000 feet-per-minute altitude increase at ANY time.

23. Slowly turn the PRESSURE ADJUSTMENT knob on the tester CLOCKWISE while closely watching the CABIN PRESSURE gage and the RATE OF CLIMB indicator.

Note: Blower pressure will be a little more than cabin pressure, due to normal leakage from the crew module. Pressurize the trainer to 5.0 psi as blower pressure is held just high enough to keep cabin pressure at 5.0 psi.

24. Do not let the temperature of the air that flows to the cabin be more than 49°C (120°F). If this happens it means there is something wrong with the cabin tester blower and the tester should be shut down.

25. When the PRESSURE RATE OF CHANGE gage starts to show a rise in cabin pressure, adjust the tester for the maximum pressure rise a 5000 feet-per-minute altitude change would need. This is done by slowly turning the pressure adjustment CLOCKWISE by 1/16 of a turn. Do this until the desired rate of increase is shown.

26. When cabin pressure is stabilized at 5.0 psi and the PRESSURE RATE OF CHANGE gage reads ZERO, find the rate of cabin leakage as follows:

a. Read blower pressure as shown on the BLOWER PRESSURE gage.

b. Find the point on the tester FLOWMETER SCALE where the vertical line (shows blower pressure) cuts the top edge of the flowmeter float (figure 2.)

READ FLOW AT TOP
EDGE OF FLOAT

Float at position
shown indicates
the following
free air flow at
the various
blower pressure
readings

<u>Press.</u>		<u>Flow</u>
<u>PSI</u>		<u>CFM</u>
0	---	118
2.5	---	124
4.5	---	130
6.5	---	137
7.5	---	140
8.5	---	144
10.5	---	150
12.5	---	158

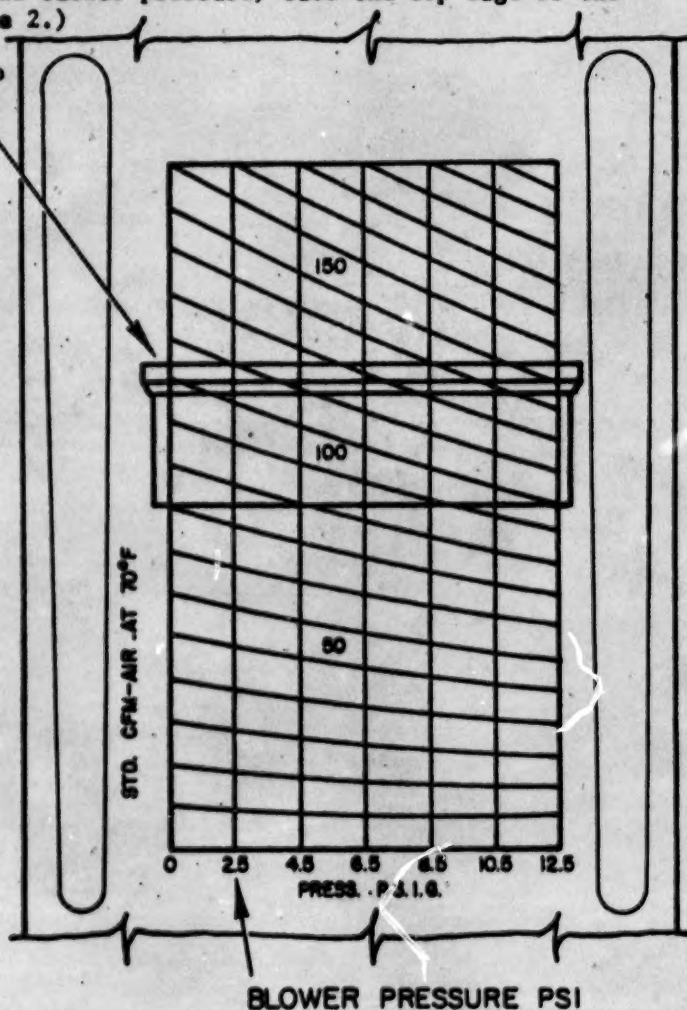


Figure 2. MB-3 Flowmeter.

c. If the point is EXACTLY on the diagonal line, read the flow (cabin leakage rate) in standard cubic feet per minute (scfm).

d. If the point is BETWEEN TWO DIAGONAL LINES, guess the distance above the lower line and add this to the value of that lower line.

e. If leakage is more than 68.0 scfm, turn to the AIR PRESSURE LEAKAGE REPAIR section of TO 1F-111A-2-2-1, for repair instructions.

Note: If the trainer cabin has too much of a leak, the leak would not be repaired. The class period is not long enough for the job.

f. If flow (cabin leakage rate) on the flowmeter is less than 68.0 scfm (5.2 pounds-per-minute), start the SHUTDOWN steps.

SHUTDOWN STEPS

1. Slowly turn the PRESSURE ADJUSTMENT knob COUNTERCLOCKWISE to minimum.

2. Slowly open the DUMP VALVE. CAUTION: Do not allow the rate of decrease in altitude to be more than 5000 feet-per minute.

3. When cabin pressure has dropped to 1.0 psi, take the unvented test caps from the COMBAT and NORMAL discharge ports and install the VENTED caps.

4. Turn the CANOPY SEAL AIR REGULATOR knob COUNTERCLOCKWISE to release pressure from the canopy seals.

Note: When the cap is removed from the NORMAL port, the 1.0 psi will vent to zero. There will not be enough pressure to cause injury or damage.

5. Push the OFF button to stop the leakage tester.

6. Unplug, remove, and stow the headsets.

7. Disconnect each hose from the tester and trainer. Stow them in the top of the tester.

8. Disconnect the tester power cable and stow it inside the tester.

9. Place caps on all ports.

10. Place the hose adapter, clamps, and handtools in the toolbox and lock it.

11. Remove and stow the safety net.

12. Open both of the cabin hatches.

13. Fold the warning signs on the outside of the classroom doors.

Note: While the cabin tester is still handy, let us talk about the flowmeter for just a minute. You can use the flowmeter to measure cabin leakage if the temperature of the air that flows through the meter is 70°F. If the air temperature is more or less than 70°F, or if the cabin leakage has to be changed from scfm to pounds-per-minute (as some aircraft TOs require), refer to TO 33A4-4-10-1, paragraph 4-9 and/or 4-10 for the correct method of figuring cabin leakage.

14. Return the TOs to the proper file cabinet.

15. Tell the instructor that you have completed the cabin pressure leakage check and he will initial your forms (that is if you did all parts of the check properly). Return to the classroom and review for the measurement.